

DISCOVERY

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Edited by JOHN A. BENN

Volume XI

JANUARY TO DECEMBER

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DISCOVERY

A Monthly Popular Journal of Knowledge

Vol. XI. No. 121.

JANUARY, 1930.

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JUNGLE RUINS FROM THE AIR
(See page 8)

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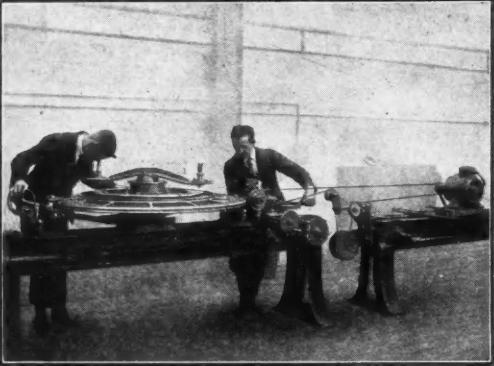
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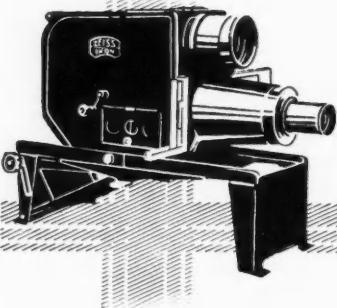
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Editorial Notes.

ALMOST all discoveries are the work of many hands, though when history comes to be written they are generally associated with single names. Sometimes it happens that credit is denied the right person until long afterwards, in other cases the public praise is justly bestowed from the outset. Then there are those inventions which owe their popularity to the men who have developed them and which might never have seen the light without such aid. The name of Henry Ford, for example, is familiar to millions who have never heard of the inventor of the internal combustion engine. Other discoveries remain anonymous, their origin lost in antiquity, and there are others to which no names become attached. Aviation has enjoyed a succession of pioneers in its different aspects, but with the exception of the Wright Brothers, its permanent contributors have yet to be decided upon. A claim for a place in the list is, however, due to Colonel Lindbergh, whose name, it appears, is already a household word for flying in America. When he made his spectacular flight across the Atlantic in 1927, he was indifferent to personal publicity, and two years of being "lionized" have left him unchanged in this respect. But from being a boy who flew for the fun of it, Lindbergh has taken on himself the mission of popularizing the aeroplane as a means of transport. One of his first efforts was a flight through each of the forty-eight States, and it was a similar expedition over South

American territory which led him to survey the Maya ruins in Yucatan.

* * * * *

As described on another page by Dr. Kidder, an official of the Carnegie Institution of Washington, this first air survey of the Maya country took place last October. Until a careful study has been made by experts it is as yet too early to tell how many of the ruins observed are new discoveries. At the same time, a conception of the country as a whole was afforded which must be of the greatest assistance to the archaeologists, whose work has hitherto been restricted by the density of the jungle. With a sense of gratitude to the aeroplane, Dr. Kidder remarks how on one occasion he was able to observe in a few seconds a swampy area which had cost him a day's difficult ground work on a previous expedition. It may be of interest to explain that this air survey was undertaken on Lindbergh's own initiative, for it was the ruins of a temple peering through the tropical jungle which had first caught his imagination, in 1928. On returning to Washington, he had at once obtained information about the Mayas from Dr. Abbot of the Smithsonian Institution, and a single evening among the treasures in the museum was sufficient to convince him of the need for a survey. While referring to this method of research, we may draw attention to the air photograph of Cambridge reproduced on page 15. It has been supplied by Aerofilms Ltd., and a similar feature will appear with all the university articles. In cases where no air photograph at present exists, it will be specially taken for *Discovery*.

* * * * *

On 14th December the Royal Research Ship "Discovery II" sailed for the Antarctic, where it will remain for three years researching on whales. The need for more exact knowledge relating to the whaling industry has long been felt, and was emphasized by the final report of the "Discovery" committee published last summer. The first ship of this name, built for Captain Scott and now being used again for polar research by Sir Douglas Mawson, had worked for some years on whaling problems, and the conclusions were reviewed

in our columns last November. As then anticipated, the future of the industry is so dependent upon a prolonged investigation of such factors as the whale food supply that further research is now to be made for the Falkland Islands Government, the owners of the "Discovery II." The ship is financed by the whaling industry in these Dependencies, and has been built at Glasgow. We had the opportunity of inspecting her just before she sailed, and noted the marked improvement in accommodation and equipment over the older "Discovery." She has a cruising speed of twenty-six knots—twice as great—and is made of steel specially constructed to resist ice-pressure. The library, necessarily limited in size, is mainly devoted to whaling literature, but we are interested to report that a full set of Benn's Sixpenny Library is included.

* * * * *

We regret to read that a terrible explosion occurred some weeks ago on board the American research ship "Carnegie," which resulted in the death of Captain J. P. Ault, the commander. As recently as November he contributed to *Discovery* on the progress of the voyage, on which the ship had been engaged for some years in discovering marine data and was to continue until 1931. The "Carnegie" was built of non-magnetic materials, to facilitate its work on electrical phenomena, and since 1909 had made several cruises of scientific character. The explosion occurred at Apia, a harbour town at Opolu Island, Samoa, and the vessel was completely destroyed by fire. Whether the scientific equipment was rescued is not yet reported, but fortunately extensive records had been regularly sent to Washington. Most of the crew escaped, but Captain Ault was thrown overboard and subsequently died in hospital. As he was navigator and chief of the scientific staff, his loss will be doubly felt.

* * * * *

An interesting discussion on the introduction of animals in countries where they are not native took place at a recent meeting of the Linnean Society. This arose from a resolution proposed by Dr. W. T. Calman, deprecating such attempts other than those urgently needed for economic reasons, or until a thorough study had been made of the new locality and the probable results. This century, and particularly the last few years, has seen a widened appreciation of the indiscriminate damage too often done to wild life, and many nature preserves have been established. But much danger is also inherent in ill-considered attempts at acclimatization. As Darwin long ago made clear, the plants and animals of a particular region form an organic whole, and

any disturbance of one link in this inter-relationship may have far-reaching effects. An example is found in the introduction of the North American musk-rat to Bohemia in 1905, of which the number in Central Europe is now estimated at over one hundred million. Other flagrant instances include the grey squirrel. An objection to the resolution was advanced in regard to its effect on plants, many of which are moved from one country to another by garden lovers and not always for economic reasons. But whether good or bad effects might predominate from some form of legislation on the matter, a conflict between the natural history and economic points of view would be bound to occur at times.

* * * * *

Imperial Airways have just taken delivery of the first triple-engined "taxi," which has been designed for long distance special charters. It is a Westland IV cabin monoplane, and incidentally is the first monoplane in this company's fleet, all the others, including flying boats, being biplanes. Four passengers are accommodated in a comfortable cabin and being seated under the wing they have an uninterrupted view of the ground below. All the usual flying instruments and controls are included, and there is a fitting often seen on motor vehicles but seldom on aircraft: a mirror in which the pilot can see the tail, also whether everything is clear, both in the air and on the ground, before he takes off.

* * * * *

Until the last few years the study of prehistoric remains in Palestine has been mainly confined to the collection of material from surface sites. In 1925 Mr. Turville-Petre, excavating on behalf of the British School of Archaeology in Jerusalem, discovered a skull of Neandertal type associated with an Upper Mousterian industry in the Mugharet-ez-Zuttiyeh, north of the Sea of Galilee. In 1928 the British School carried out the excavation of a cave in the western Judean hills, where an industry resembling the type near Galilee was found underlying a Mesolithic level, hitherto unknown in Palestine. In the autumn of the same year a carving on bone, which appeared to be prehistoric, was discovered in a sounding made in the Mugharet-el-Nad, at the western foot of Mount Carmel, and in 1929 this cave was excavated by British and American archaeologists. The results of this work were described at the Royal Institution on 13th December, when Miss Garrod pointed out that the undisturbed inner chamber of the cave contained five prehistoric levels, three of them Upper Palaeolithic. In these layers it was found that North African and European influences alternated.

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What We Found on the Barrier Reef.

By C. M. Yonge, B.Sc., Ph.D.

Leader of the Great Barrier Reef Expedition.

Following the article on the geography of the Australian Barrier Reef, published in our December issue, we print an account of the main work of the expedition in regard to biological problems. Much has now been discovered about this remarkable formation, the largest and most imposing coral reef in the world.

THE Great Barrier Reef Expedition was organized by a committee of the British Association, but had been invited out by the Australian Committee which has its headquarters at Brisbane. This Committee, formed since the war largely as a result of the enthusiasm and work of Sir Matthew Nathan, the late Governor of Queensland, and of Dr. H. C. Richards, Professor of Geology in the University of Queensland, had already done notable work, particularly geological and geographical, and felt that the time was now ripe for an expedition on a large scale to examine the Barrier from the biological standpoint. There were in all seventeen scientific members of the expedition, three of whom formed a geographical section. (The geographical work was under the direction of Mr. J. A. Steers, who gave an account in *Discovery* last month.) Of the remaining fourteen members, who formed the main biological party, one was a chemist, one a botanist, one a medical, and the rest were zoologists, including two Australians. There were many visitors representing the Barrier Reef Committee and a number of the Australian universities, while five members of the Australian Museum at Sydney did extensive collecting.

Low Island.

Low Island was well chosen as the headquarters of the expedition, which stayed there from 16th July, 1928, to 28th July, 1929. A little over forty miles north of Cairns, the last town of any size on the north Queensland coast, and midway between the inner edge of the Barrier and the coast, here some fifteen miles apart, it was conveniently situated for reef work and yet not too far from the main base of supplies. The latter were obtained *via* the little town of Port Douglas seven miles away. The lighthouse was tended by three keepers who lived, with their families, on the island. Every fortnight a store-boat came out to them; the expedition also made use of this vessel and supplemented the service in the alternate weeks by sending in its own vessel. This boat, on which all communication as well as regular sea work depended,

was a ketch-rigged yacht called the *Luana*. She was a thoroughly seaworthy craft, thirty-nine feet long, with a powerful auxiliary motor. Mr. A. C. Wishart of Brisbane, the owner, himself ran her, and was assisted by Mr. H. C. Vidgen, also of Brisbane, who directed the work of the two aboriginal boys who did rough work on the boat and about the island. A half-caste aboriginal woman acted as cook, very satisfactorily, and her husband, a pure aboriginal, as houseboy and general factotum. Their two small children completed the aboriginal population, although for a short time another boy was employed to assist the reef party. All these aborigines came from the Anglican Mission at Yarrabah, near Cairns.

Special Buildings.

The months immediately before the arrival of the expedition were periods of great activity on Low Island. Along the southern shores a series of huts were built, first a laboratory and dining-room combined, with a small kitchen attached; then a large hut divided into rooms for the married people and single ladies, with a store for provisions at one end; a hut for the single men, behind this a bathroom, and last of all a hut for the aborigines. After the arrival of the party, the laboratory hut was fitted up with shelves, aquaria were made, a dark room built at one end of the married quarters, a tropical meteorological hut constructed—in which were exposed the thermometers, thermograph and hydrograph—and a hundred other smaller operations were carried out. The two islands lay on a common reef which was widely exposed, between and around them, at low tide. On the south-easterly side—against which the trades winds drove the sea for nine months in the year—the reef edge presented an unbroken crescent, but on the northerly side it shoaled gradually and made a natural harbour, protected on either side by outrunning spurs of the reef and with a safe sandy bottom. Here lay the *Luana* and the three smaller boats which composed the fleet, and only in the summer when occasional storms came from the north straight into the



LOW ISLAND AT HIGH TIDE.

The huts occupied by the expedition are seen at the top of the beach, with the lighthouse in the centre.

anchorage, or during exceptionally strong south-easterly gales, was it necessary to haul the small boats high on to the beach and send the *Luana* into Port Douglas harbour for shelter.

Although without the clear water and absolutely ideal conditions for coral growth found further from land along the Barrier, Low Island reef proved to be rich in coral of very many genera and species, and provided a first-rate site for the detailed observational and experimental work on corals and other reef organisms which formed a large part of the programme of the expedition. Routine hydrographic and plankton work was carried out from the *Luana* at a station three miles to the east of the island, and comparative work carried out over the reef itself and within the mangrove. On the work done on and about Low Island the expedition will be judged. But in order to make the work as extensive and general in character as possible, small expeditions were sent up and down the Barrier, examining the reefs, taking plankton samples, collecting hydrographic data, dredging and trawling on the sea bottom, and inquiring into the economic possibilities of various regions. Large motor launches of more power and greater accommodation than the *Luana* were hired, and a series of cruises as far south as Trinity Opening, opposite Cairns, and as far north as the Howick Islands beyond Cooktown, were made. The stretch of reef and channel between these two points, almost two hundred miles apart, was everywhere dotted with the collecting stations and observational areas of the expedition. Parties also visited Thursday Island and other parts of the Torres Straits, including Murray Island, a volcanic island of great beauty, just within the far northern extremity of the Barrier; and the Capricorn Islands at the southern extremity, situated, as their names indicate, just on the Tropic. Finally hydrographic data were

collected on a trip to Willis Island, a minute coral island two hundred miles from the coast and the site of the Commonwealth Meteorological Station.

Having considered the site of the expedition and its far flung sphere of operations, we may now discuss the work done on the island. For convenience of work the expedition was divided into three sections, a Boat Party, a Reef Party and a Physiological Party.

The main objectives of the Boat Party (in charge successively of Mr. F. S. Russell and Mr. A. P. Orr) were to determine the chemical and physical conditions of the sea water, and the nature and bulk of the plankton, paying especial attention to any changes that might occur during the year. In temperate seas, such as the British Channel, the plankton varies greatly throughout the year, and these variations can all be traced back to the amount of sunlight (on which, of course, the plants are absolutely dependent) and the amount of dissolved nutrient salts—especially nitrates and phosphates—in the sea. No similar work had ever been undertaken in tropical waters, and it was not known whether the same cycle of events occurred there or not. Regular weekly stations were carried out by the Boat Party throughout the year. Samples of sea water were taken at definite depths by means of the insulating water bottle and the temperature, salinity, oxygen, phosphate and silica content, and hydrogen ion concentration, regularly determined. At the same time plankton samples were taken with various grades of silk tow nets, and with the larger, stramin (a kind of sacking) nets. These nets were let down to a definite depth and then towed at a constant speed and for a definite time, being slowly hauled in at the same time so that the nets took their sample obliquely through the upper layers of the water. In this way errors due to the difference



EXPERIMENTS ON CORAL GROWTH.

Corals were cemented on concrete blocks and their growth photographed at regular intervals. Elaborate precautions were taken to ensure accurate measurements.



VIEW OF THE REEF FROM THE LIGHTHOUSE.

The exposed reef flat at low water is here seen from the top of the lighthouse on Low Island. The region beyond the sand spit in the middle distance was the zone of experimental operations carried out by the expedition.

in level of the plankton according to the time of day or state of the weather—for the position of the plankton is controlled by the intensity of the light—were obviated. The smaller phytoplankton was collected in silk nets lowered vertically over the side of the boat and then drawn slowly up, or in the water bottle, the samples in the latter case being later centrifuged.

The catches each week were worked through in the usual way, that is, definite samples were taken and the numbers of every kind of organism counted, the figures so obtained being multiplied so as to bring the numbers up to the figure approximately representing the entire catch. The results of the hydrographic and plankton work were clear enough. Instead of the spectacular seasonal variations which occur in temperate seas, the plankton remained, except for small variations due to sudden swarms of particular animals or plants, practically stationary in numbers throughout the year. The explanation of this was furnished by the discovery that the quantities of nutrient salts remained constantly low. In such tropical regions the seasonal changes, so obvious and so all-important in our own seas, are almost entirely absent.

The plankton and hydrographic work was far from being an end in itself. A proper study of coral reefs demands, above all, the most exact possible information about their environment, and their environment is the sea which surrounds and washes

them. Although coral in deep water is never subjected to great differences in temperature, salinity, oxygen content, and so forth, the corals on the surface of reefs which uncover daily at low tide have to withstand very great changes. A long series of analyses of the water over the reef flat at Low Island was carried out, the samples being taken at regular intervals over twenty-four hours, and the results obtained showed how great must be the powers of resistance of corals to changes in the condition of the sea water. For example, temperature rose very high at low water and also salinity, owing to evaporation; the oxygen content rose to about double saturation at low tide in the daytime, owing to the action of the algae which live in the coral, while at night the oxygen content fell greatly while the tide was out. The effect of sediment on the growth of coral has always been emphasized by former workers, who considered that coral could not grow in water in which more than small amounts of sediment fell. This matter was investigated in greater detail and by more quantitative methods than had ever been done previously, and our general conclusions were to the effect that corals can withstand even a heavy fall of sediment. Indeed, the largest quantities of sediment were collected in regions where coral were most abundant.

All work connected with the composition of the reefs, the species of corals and associated animals and plants and their habits, was in the hands of the Reef

Party, of which Dr. T. A. Stephenson was in charge. Their largest piece of work consisted of detailed ecological surveys of Low Island Reef, of Three Isles—a similar formation some distance north of Cooktown—and of a section of the Outer Barrier. A general census of the reef population was made and also, especially on Low Island, the numbers of every type of animal and plant on certain selected strips were counted. This work was carried beyond the edge of the reef flat as it uncovered at low tide, by means of a diving helmet of the type recently made popular by the writings of Dr. W. Beebe. This helmet fits over the head and is kept down by heavy weights adjusted in front and behind. Air, sent down by means of a small double acting motor-car type pump, is delivered into the side of the helmet through a length of garden hose. The diver, who wears a bathing costume and shoes, is let down and hauled up by means of a life line of thin rope fastened to the top of the helmet.

Obscure Questions.

The whole question of coral reproduction and development is still very obscure. Corals reproduce themselves by means of minute, pear-shaped or oval larvae, known as planulae. These are discharged into the water in great numbers where they swim about by means of thread-like cilia with which they are covered, until such time as they are fortunate enough to encounter a clean hard surface when they quickly settle down; at the opposite side to the area of attachment a mouth appears, round this a ring of tentacles, while within the tissues develops a delicate skeleton. Soon after this, buds develop around the first polyp and the colony has begun. Two Low Island corals, *Pocillopora* and *Porites*, shed planulae abundantly, and we were able to study in great detail the process of development of the colony from the planulae. Frequent examinations of a number of corals were made so as to discover the period at which the sexual products were ripe, and planulae capable of being formed. Even more extensive work of this nature was carried out on the breeding season of some dozen representative reef animals. The most interesting result obtained was with a chiton which discharged its eggs regularly for many months in succession on the night of full moon.

In order to estimate the rate at which coral reefs are formed it is essential to know the speed of growth of the different corals. We carried out an elaborate experiment, having a great number of square concrete blocks made and cementing to the top of these selected corals. The blocks with the attached corals were



ANIMALS WHICH SPAWN AT FULL MOON.

The chiton *Acanthoaster gemmata*, an animal about four inches long, everywhere common on dead coral boulders. It spawns regularly at full moon.

placed in the water as soon as the cement had set. To determine the rate of growth, photographs were taken of the coral and blocks, before and after the experiment, which lasted six months. A special staging was used for this, and precautions observed to ensure that the photographs were taken from exactly the same distance and angle on both occasions. Detailed analyses of the photographs will take much time, but a casual glance showed that some corals doubled their size in six months.

Amongst the many agencies which cause the destruction of reefs, not the least potent are the many kinds of animals which bore into the coral limestone. The most important of these are the bivalve molluscs, especially the genera *Lithodomus* and *Gastrochaena*, and these were exhaustively studied.

Apart from business concerned with the running of the expedition and supervision of all dredging operations, the writer's own work consisted of physiological studies of corals and of a few important reef molluscs. The greatest problem was concerned with the nutrition of corals. Although corals, in common with all related animals such as jellyfish and sea anemones, possess sting cells for paralysing animal prey and, except in a very few cases, tentacles for seizing such prey, many zoologists have considered that either there was not enough animal plankton to nourish them or that in many cases the polyps were incapable of capturing and dealing with such food. Since corals obviously do feed and flourish some other source of food was sought. The tissues of practically all reef building corals are packed with minute brown bodies which examination shows to be algal cells. These have been claimed as the auxiliary food supply of the corals.

Our work at Low Island failed to confirm this. Even

the corals with the—apparently—most degenerate polyps were found to be perfectly capable of capturing their prey, though in every case they refused to have anything to do with vegetable matter. A detailed chemical study of the digestive ferments of corals showed that flesh was quickly digested but starchy matter left unchanged. Other experiments showed that, though the algae were freely expelled in a dead or dying state when the corals were exposed to unfavourable conditions, such as continued darkness, high temperature, starvation, or lack of oxygen, they never appeared to be digested by the corals. But the presence of the algae may be of great value to the coral in this way. Like all other plants, as a result of photosynthetic activity, they produce oxygen. Prolonged series of experiments were made to determine the amount of oxygen produced and the conditions most favourable to this and, while it is difficult to conceive of any way of definitely proving it, there does appear to be reason to think that the corals are greatly benefited by this auxiliary supply of oxygen. The algae certainly benefit by the partnership, they receive protection, are exposed to the light, have abundant supplies of the necessary carbon dioxide gas and nutrient salts such as phosphates and nitrates, all of which are excreted by the coral. The manner in which the calcium carbonate which forms the skeleton of the coral is produced was studied. This proved a most difficult problem and, though a number of means

whereby this process does take place were effectively disposed of, the actual process remained undiscovered.

Corals are not the only animals to possess algae. The clams of the genera *Tridacna* and *Hippopus*, which are everywhere abundant, and range in size from the giant clam exceeding four feet in length, to the burrowing clams six inches long that literally cover the surface of many dead coral boulders, also have symbiotic cells.

Space allows only brief mention of the economic work of the expedition, which included not only a general survey of the economic possibilities of the Barrier but also detailed work on animals of such proved value as the pearl-shell oyster, *Trochus* shell (a large marine snail, the thick mother-of-pearl from whose shell is used for the manufacture of buttons), *bêche-de-mer* (holothurians or sea cucumbers which are dried and exported to China), sponges, edible oysters, and the most important food fishes. Much work of value was done in the twelve months, but this is to be merely the beginning, for Mr. Moorhouse (who was in charge) is being retained as fishery investigation officer by the Government of Queensland and will continue this research as well as extend it to other animals, such as turtles and dugong, which were not common around Low Island. The buildings and equipment at Low Island were handed over to the Queensland Government to form the basis of a permanent marine station.



EXPOSED CORAL (LARGELY ACROPORA) AT PIXIE REEF, TWENTY-FIVE MILES FROM LOW ISLAND.

The Maya Country from the Air.

By A. V. Kidder.

Head of the Staff of Early American History, Carnegie Institution.

The first aerial survey of the famous Maya ruins was made in October by Colonel Lindbergh, the American airman, in co-operation with the writer. Several thousand miles were covered and it is believed that more ancient temples, hitherto unknown, have been discovered. The air photographs were taken by Mrs. Lindbergh.

COLONEL LINDBERGH'S recent air survey of the Maya region of Central America affords a fine example of the value of team play. When a great aviator, a great transportation company, and a great scientific agency put their shoulders to the same wheel, that wheel is bound to turn. The project grew out of a combination of agencies and of interests. First, there was Colonel Lindbergh, who is always seeking opportunity to demonstrate the utility of the aeroplane. On a former flight his curiosity had been aroused by glimpses of

ancient jungle-buried cities. Then there was the Pan-American Airways, Inc., a company engaged in spreading a network of flying trails over Latin America, and, lastly, there was the Carnegie Institution of Washington whose staff of archaeologists, earth-bound in the forests of Yucatan for years, had longed for the sweeping view which the aeroplane alone can give. Such was the group that has successfully concluded the only aerial survey ever made of the Maya region of Central America.

Belize, once a stronghold of buccaneers, now capital of British Honduras and an important airways base, was the rendezvous. We met there on 5th October. Colonel and Mrs. Lindbergh were finishing a trip round the Caribbean. Oliver Ricketson, archaeologist, came down from his headquarters in Guatemala City. W. I. Van Dusen of Pan-American Airways and I flew from Miami. That evening we laid plans and gathered equipment. Our general objectives were to test the aeroplane as an agency for archaeological exploration in tropical countries, and to find out whether the ruins of Maya cities could be located from the air. Above everything else, we wished to get an idea of what the Maya country really looks like.

Although archaeologists have been pushing their way into the region for many years, they have been so buried in the welter of forest, their outlook has been so stifled by mere weight of vegetation, that it has been impossible to gain a comprehensive understanding of the real nature of this territory, once occupied by America's most brilliant native civilization. Such understanding is absolutely necessary, because all people, ancient and modern, are largely products of their environment. Hill and plain, watercourse and cultivable land, shape





THE SITE OF CHICHEN ITZA AS SEEN FROM THE AIR.

The famous Temple of the Warriors is seen in the right background, while on the left is the Ball Court. The circular tower nearer the camera is the Caracol, believed to have been erected for astronomical purposes. Chichen Itza was probably founded not later than A.D. 500.

the destinies of nations more powerfully than battles.

The labours of many explorers and scientists have made clear the fact that long before the time of Christ there arose in the New World an independent civilization which culminated in the great cities of the Maya Old Empire. These cities were built and occupied while Europe was in the Dark Ages, but they, like Rome, fell, and their high tower-temples and many-chambered monasteries were engulfed by the jungle. The Maya people then moved northward into what is now Yucatan, took on a new lease of life and again constructed cities, many of which persisted until the coming of Europeans put an end to all native American development. Archaeologists have pieced together a fairly consistent outline of this history, but of the Maya country as a whole, of the "lay," so to speak, of the land, we have had, until Colonel Lindbergh's recent flights, only the scantiest knowledge.

Our problem was clear. We must cover as much of the area as possible, and learn all we could about it. Our equipment was ideal, a Sikorsky amphibian machine from the Pan-American fleet, capable of sustained flight with either of its twin motors. It carried a radio outfit, a collapsible rubber boat and

emergency rations. Colonel Lindbergh, with his usual thoroughness, added a shotgun in case a forced landing made it necessary to live on the country, and hammocks, cooking kit, canteens and medicines. The general plan was to strike first into the heart of the Old Empire region in northern Guatemala and then turn north to fly the entire length of Yucatan in a single "hop." This would necessitate refuelling at Merida at the extreme northern end of the peninsula. As the distance was so great, and as landing-places were probably non-existent, weight had to be cut to a minimum in order that should one engine fail, the plane could be counted upon to "hold up" for several hundred miles.

After taking off from the harbour of Belize on the morning of 6th October, the machine flew up the Belize River, cutting straight across its thousand loops and bends, high above the rapids and shallows that make boat travel so slow. A hundred miles inland the plane turned northward into the Peten region. In a few minutes the roof-combs of the great temples of Tikal, queen of the Old Empire cities, became visible. After circling low for photographs, a straight shot was made for Uaxactun the oldest known Maya city. This site, which

Ricketson has been excavating for the past four years, was discovered in 1916 by Dr. S. G. Morley.

From Tikal to Uaxactun is a very long day's journey by mule-train, a journey which is made possible only after the trail has been cleared. The aeroplane did it in exactly six minutes! Ricketson's clearing and camp, and the strange, squat, grotesquely sculptured pyramid which he has laid bare were clearly visible, and were photographed as Lindbergh wheeled close above the tree-tops. Beyond Uaxactun lay unknown, uninhabited country, and Merida was still four hundred miles away; hence no deviation could be made from a direct northward course. The sea of jungle proved to be unbroken. Hour after hour the green floor of the tree-tops flowed back under the speeding plane. Ninety miles beyond Uaxactun there appeared a flat-topped pyramid surmounted by two temples, the culminating structure of a forgotten and forest-swallowed city. This may be new or may perhaps be a site called Rio Becque, discovered in 1912 by R. E. Mervin, of the Peabody Museum.

Northward again the plane sped, over vast stretches of green, until the palm thatched huts of the first small frontier settlements of Yucatan were reached. Everyone breathed a little easier in the feeling that they were again over the homes of living men. Thence onward the towns became larger. The forest was dotted with the clearings of Indian cornfields. Finally Merida came into sight, and soon the plane settled down upon the landing field. The party were overnight guests of Governor Torre Diaz, who has done so much to forward the excavations in Yucatan. The first objective of the next day was Chichen Itzá, largest of the New Empire cities, whose temples and pyramids, cleared by the Mexican government and by Carnegie archaeologists under Dr. Morley's direction*, showed snow-white against the green "bush."

After leaving Chichen Itzá the party turned southward and laid a course for Belize somewhat to the east of the route which was followed the day

before. On this return trip the plane passed over country hitherto untravelled; country so densely overgrown that no trace of ruins could be discerned. The flights of these first two days covered approximately a thousand miles, much of it over regions never traversed by white men, and none of it ever before seen from the spreading viewpoint of the air. At our conference on the evening of the return to Belize we decided that we must definitely train ourselves to recognize tree-shrouded mounds and pyramids, to pick out from above, the vague, masked outlines of plazas and temples.

Next day we struck out again for Peten searching for ruins whose general location we already knew. In this way there were picked up the cities of Yaxha and Nakum, and by repeated low circling we taught ourselves this new technique of sky-spying. Soon we were off to Tikal and Uaxactun, thence eastward to a small ruin (probably new) that could be made out on the skyline from above Uaxactun, and so to the Laguna de Peten, where the Guatemalan outpost town of Flores crowds a tiny island in the lake. We paid our respects to the governor, who came out in a launch to greet us, surrounded by the entire

population in dug-out canoes; and then rose to fly southward over a vast, flat stretch of alternating savanna and woodland, toward the northern tributaries of the Pasión River. These streams traverse a terrible and (to fly over) a most terrifying country, a confused welter of gorges and limestone pinnacles smothered in a jungle so dense, so intertwined, so utterly hopeless to penetrate, save through the foot-by-foot hacking of trails, that I think no one of us failed to give a sigh of relief when we soared over an outlying spur of the Cockscomb Mountains, dodged between two rain-squalls, and saw to the eastward the silver glimmer of the sea.

The next few minutes brought one of those incredible transitions possible only to the air traveller. We swung to the north, dipped across the coastline and landed on the smooth water miles out in the Gulf of



JUNGLE PYRAMID AT UAXACTUN, GUATEMALA.
A remarkable structure dating from about two thousand years ago and discovered in 1916. It is built of uncut stone, faced with white stucco.

* Described in *Discovery*, January, 1928.

Honduras. After anchoring the plane, we pumped up the rubber boat and rowed ashore. Half an hour after being over that ghastly, broken, interior wilderness, we were comfortably cooking lunch under the palms by the coral beach.

On the fourth day we took off a little after ten o'clock, passed northward over the coastal swamps, turned inland, and in an hour were beating across the jungle west of Lake Bacalar, where, thanks to our practice of the day before, we were able to pick up three sets of mounds, one of which was evidently the centre of a very extensive city. Here we saw four high pyramids, upon two of which the white walls of temples could be observed. Colonel

Lindbergh then climbed to two thousand feet and headed north across the great, flat plain of Yucatan. There were no hills or valleys to break the even spread of the tree-tops. Soon we began to see the sharp eminences of groups of ruins.

These groups, most of which are probably new, were plotted by compass-course and flying time. In some cases, they were still more definitely located by means of bearings taken on distant landmarks. For an hour or more we tacked back and forth, noting sites in all directions, flying close over the largest ones and gradually working north until we saw poking up on the horizon the enormous mounds of Cobá, an ancient Maya site which has been visited by fewer than a dozen white men. By one-thirty we were over it, anxious to land on one of the two little lakes about which the great forest-buried buildings are grouped. We dipped and skimmed the water, but Colonel Lindbergh shook his head at the high trees on the farther shore, and we rose again to circle the tall *castillo* and cross in a moment a swampy lowland that three years before had cost Eric Thompson and the writer a full hour of bitter struggle.

Until now everyone had been too busy to think of lunch, but when we swung high again and headed for the coast Mrs. Lindbergh produced chocolate biscuits and coffee. By the time we went ashore at

the seaside ruin of Tulum we had been well fed. That night we stayed at Cozumel Island, where Pan-American Airways has a base, revisited Cobá next morning to recheck our observations, and by ten o'clock were headed for Cuba, Miami and home.

During the flights everyone was constantly busy: Colonel Lindbergh with map on knees kept track of courses, wind-drift, and estimated distances to and between objects sighted. Mrs. Lindbergh, whose eyes are very keen, watched the bush and took the photographs. Van Dusen, through Ehmer, our wireless operator, sent bulletins of progress to the aeroplane bases at Miami and Belize. Ricketson and

I filled notebooks as fast as we could write, jotting down observations on topography, nature of forest, occurrence of lakes, streams, swamps and descriptions of the appearance of the ruins passed over.

The greatest thrills of our five days' flying came, of course, with the finding of groups of Maya ruins indicating the presence of ancient cities. Although we believe it probable that four of these are new to archaeologists and that possibly two others also have never been visited, we cannot be quite certain until all existing maps and the literature of exploration

have been carefully checked, and until ground parties have examined them. However, the purpose of the expedition was much more than the mere discovery of ancient sites. It was planned and carried out as a test, a reconnaissance, to gauge the value of the aeroplane for survey and observation. We proved to our satisfaction its unique usefulness in enabling scientists to study such a country as a whole, to record its geographical features, to note the nature, distribution and extent of its forest types, and to plan routes and fix landmarks for ground exploration.

It is certain that in many regions the aeroplane can be used to transport, set down on lakes or savannas, and pick up again, small parties of scientific workers, thereby enabling them safely and easily to cover, in weeks, territory which would require months and whole seasons of difficult and dangerous ground travel.



TULUM, ON THE YUCATAN COAST.
This first air photograph of the largest and best preserved Maya city shows the wall which cuts off the area on three sides from the tropical bush.

British Universities To-day : (1) Cambridge.

By A. C. Seward, Sc.D., F.R.S.

Master of Downing College and Professor of Botany.

We introduce here a series of articles on British Universities, the first by Professor Seward, who was Vice-Chancellor of Cambridge in 1924-6. Early history is discussed to show how the traditional organization has adapted itself, and some estimate is made of the University's contribution to modern life and progress.

LITTLE is known of the inception and early stages in the development of the University of Cambridge ; it is said to have originated in the twelfth century, and "it is almost certain that before the beginning of the thirteenth century it was a recognized centre of study." About the year 1220 the fame of Cambridge as a seat of learning attracted Franciscans who established themselves on the site now occupied by Sidney Sussex College ; a little later Carmellites settled close to the ground on which Queens' College was built. Before the end of the century Dominicans built a friary, a few walls of which still survive in Emmanuel College. In 1261 it is probable that the scholars of the University were divided into nations as at Bologna, Paris, and Oxford. In 1318 Cambridge received from Pope John XXII formal recognition as a *Studium Generale* or *Universitas*. The University was incorporated in the reign of Queen Elizabeth under the name of "The Chancellor, Masters, and Scholars of the University of Cambridge" and received a grant of arms in 1573 with the motto *Hinc lucem et pocula sacra*. The arms are : gules, a cross, ermine and four gold leopards with a book, gules upon the cross.

Six Centuries of Tradition.

The first college, Peterhouse, was founded in 1284 by Hugh de Balsham, Bishop of Ely. Of the eighteen colleges which now constitute the University—the others, in the order of their foundation, are Clare, Pembroke, Gonville and Caius, Trinity Hall, Corpus Christi, King's, Queens', St. Catherine's, Jesus, Christ's, St. John's, Magdalene, Trinity, Emmanuel, Sidney Sussex, Downing and Selwyn—all had been established by the end of the sixteenth century, excepting the two last named, founded respectively in 1800 and 1882.

In 1869 undergraduates began to be admitted as "Non-Collegiate Students" : in 1892 the Board responsible for the admission of these students acquired Fitzwilliam House, in Trumpington Street, which serves as a corporate centre and supplies some of the amenities of college life. There are also two colleges



recognized by the University as institutions for the higher education of women, Girton College founded in 1869, and Newnham College founded in 1871. Women students are admitted under certain conditions to University lectures and laboratories on the same terms as the men. There are in residence this academic year 4,827 undergraduates, distributed among the eighteen colleges and Fitzwilliam House. There are also 369 Bachelors of Arts, 181 Advanced Students and 1,083 Masters of Arts, making a total of 6,460 members.

The University is a corporation with undergraduates and graduates as members ; it is not concerned with the food and lodging of the students "beyond the exercise of a superintending power over the rents and regulations of the houses in which they are lodged, in order to protect them from exaction ; and it also assumes the care of their public morals." The Colleges are corporate bodies distinct from the University ; they are self governing, manage their own property, and elect their own officers. The relation between the Colleges and the University is one of the most difficult things to explain to visitors : College buildings dominate the town, and though they are in effect part of the University, they are not in the strict sense University buildings. A lady from a foreign country whose determination was greater than her knowledge of Cambridge, wished to become a member of one of the Women's Colleges ; on arriving at the station she asked a cab-driver to take her to the University : being a man of intelligence he drove her to the Senate House, though, for the purpose of interview, the closed doors were discouraging. The Senate House may be described as the centre of the University : other University buildings include the Library, the University Church (Great St. Mary's), and the University Press, in addition to the numerous Laboratories and other buildings used for administrative purposes or for teaching and research.

The Colleges are required by statute to pay an annual contribution to the University. Members of the teaching staff of the University—Professors, Readers,

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Lecturers and Demonstrators—are appointed by the University, and their duty is to give instruction to students from all or any of the Colleges. There are also some College Lecturers, but most of the teaching within the walls of a College is of less formal character, and is done by Supervisors, who, in recent years, have largely replaced the independent coaches. Supervisors are accessible to students who need, or think they need, assistance in subjects on which they are attending University lectures.

Many University teachers hold also College posts : some are College Tutors or perform other College duties, and many of them are Fellows of Colleges. The Colleges are societies composed of Fellows, some in receipt of dividends from the corporate funds, others non-stipendiary ; also undergraduates (including Research Students) and Bachelors of Arts, who dine in the College Hall and live either within the precincts of the College or in lodgings licensed by the University, and selected by the College Tutors. The University has certain disciplinary powers vested in the Proctors, who are nominated by the Colleges in turn, and elected by the University. Colleges are responsible for the discipline of their own undergraduates, and students may be sent down temporarily or permanently without reference to any University authority : cases of breach of discipline outside the College buildings are dealt with by the Proctors either directly or after consultation with the Tutors of Colleges. Each College has its Council or Governing Body : the chief University body is the Council of the Senate, consisting of the Vice-Chancellor and sixteen members elected by the Regent House. Other University bodies are the General Board of the Faculties, responsible for educational policy, the Financial Board, in control of University finance, and numerous Syndicates and Boards.

Senate and Chancellor.

The Vice-Chancellor, chosen from among the Heads of Colleges, and appointed by the Regent House, is the acting executive head of the University. Early in the fifteenth century it was stated that "the Chancellors of Cambridge being lately either persons of noble birth or great employment, whose occasions often caused their absence, it was fashionable henceforward to substitute Vice-Chancellors in their room." Under the present Statutes the Senate, consisting of Masters of Arts and holders of higher Degrees who have fulfilled certain conditions, has comparatively little power : it is the duty of the Senate to elect the Chancellor and a few other officers, to vote upon proposals for the conferment of Honorary degrees,

and, in certain circumstances, to vote on appeals from the Regent House. The Regent House, consisting almost entirely of graduates in residence who are engaged in University or College work, has much wider powers than the Senate.

The New Statutes.

After this very incomplete sketch of the constitution of the University and of the relation between the University and Colleges, we may consider in a very general way some of the differences between Cambridge as it is and as it was a few decades ago. In 1926 new Statutes were approved by the King in Council : some of the more important changes for which the Statutory Commission is responsible may be mentioned. The Regent House was established in order to place in the hands of the graduates in close touch with teaching and administration most of the executive responsibility previously vested in the much larger body—the Senate, which consists not only of resident but of many thousand non-resident graduates. The new Statutes also compelled Colleges not to admit, or to present for matriculation as members of the University, students who have not passed or obtained exemption from the whole of the Previous Examination (" Little-Go "). The Commissioners recommended that Colleges should not allow students whose work or conduct is unsatisfactory to remain in residence, whether on grounds of athletic distinction or for other reasons. Members of Girton and Newnham Colleges are now granted titles of degrees and women have the right to hold University posts.

One of the most far-reaching changes was the introduction, or rather the extension, of the Faculty system. Under the old Statutes there was unnecessary duplication of teaching, an overlapping of University and College courses : now the teaching is co-ordinated, and definite scales of payment have been established, irrespective of the amount of fees paid by students. Regulations have been made to avoid the danger of College duties interfering unduly with the discharge of University obligations. Another reform is the fixing of a retiring age of sixty-five for Professors and other University officers, and the institution of a much needed pension scheme. Heads of Colleges may continue in office up to the age of seventy. Colleges are now taxed by the University on a graduated scale, and this is a substantial assistance to the poorer Colleges. The foundation of a Board of Extra-Mural Studies is another wise step which has been taken in recent years ; this Board is responsible for the organization of instruction of persons who are not members of the University by means of University

Extension lectures or tutorial classes under the Workers' Educational Association. Before the new Statutes came into force the University as a whole received no financial assistance from the Treasury : a few Departments, notably the Department of Agriculture, had been assisted by Government Grants. The changes in University administration necessitated under the new Statutes required a considerable increase in annual expenditure, and this was partially met by a substantial Government Grant.

New Professorships.

The vital question is, can Cambridge claim, despite its antiquity and its classical and theological traditions, to have taken a share commensurate with its reputation as a seat of learning in the encouragement of Science and other modern branches of knowledge? It is not too much to claim that Cambridge occupies a pre-eminent position as a centre of scientific teaching and research. The Faculties of Theology, Classics, and other departments are still vigorous ; their methods have been modified and developed in accordance with the modern trend of thought. The Mathematical School retains its well deserved reputation, and the same may be said of History, Economics, and Law. It is true that the introduction of many fresh avenues to a Degree has considerably reduced the proportion of students reading the older subjects, but the quality of those who take Classics and Divinity, because they prefer these subjects and not because it is the proper course to follow, has not deteriorated. Since 1918 Chairs have been established, in several instances through private benefactions, in Italian, Naval History, Aeronautical Engineering, Physical Chemistry, Biochemistry, Animal Pathology, Mathematics (an additional Professorship), Political Science, English Law, Economic History. The erection of new Laboratories has been proceeding almost without a break for several years past : the latest addition is the large Pathological Laboratory, for which the necessary funds were mainly provided by the Rockefeller Trust. In recent years the Engineering Department has been rebuilt and very greatly extended, and substantial additions have been made to the School of Agriculture.

The outgoing Vice-Chancellor, in his Address to the Senate on 1st October, referred in the following words to the most princely benefaction the University has ever received : " The year has been remarkable for the magnitude of the benefactions which have been offered to the University. My predecessor in his Address last October made an announcement concerning the offer of the International Education Board (one of the

Rockefeller boards) of the sum of £700,000, partly for the endowment of the Agricultural, Physical and Biological Sciences, and partly for the new Library. In order that the University may be able to claim this magnificent benefaction we are required to obtain from other sources a capital sum of £479,000 which, together with the £700,000 offered by the Board, will make up a sum of £1,179,000. Towards this sum the University is allowed to reckon the sum of £250,000 which it had previously undertaken to contribute as one half of the sum estimated as necessary for the new Library." Towards the remaining £229,000 substantial donations have been received, and we hope in due course to obtain the balance. It would be difficult to cite a more encouraging expression of confidence in the University than this selection of Cambridge by the International Education Board for exceptional treatment from among the universities of the world.

Science and Industry.

As additional evidence of progress, and incidentally of the opinion of Cambridge held by a Department of our own Government, mention may be made of the recently erected Low Temperature Station, built and endowed by Government money, staffed and directed by members of the University. This station affords a good example of the application of pure science to industrial problems, particularly problems connected with the preservation and transport of meat and fruit from Australia, New Zealand, and other countries. The rapid development in recent years at Cambridge of Departments of Applied Science is one of the more obvious signs of the time. Our aim is still to provide a sound training in pure Science.

In 1921 the University established an examination in Architectural Studies for the Ordinary B.A. Degree. The University grants Diplomas in Geography, Anthropology, Medical Radiology, Psychological Medicine, Hygiene, Public Health, Tropical Medicine and Hygiene : Geography is also a subject for both an Honours and an Ordinary Degree.

The development of Post-graduate work has made rapid progress during the last few years : there are in residence this year 350 Research Students, the great majority of whom are preparing theses for the Ph.D. Degree ; a small number are candidates for the degrees of M.Sc. or M.Litt., which are also obtained by research. Of these Research Students about one hundred are graduates of Colonial or American Universities. Other students engaged in Post-graduate study are sent to Cambridge by the Colonial Office, some to prepare for administrative



CAMBRIDGE FROM THE AIR.

posts in the Crown Colonies, some to qualify for agricultural research in tropical countries.

Leaders of Men.

The University has in recent years been brought into close touch with the Royal Engineers, the Signal Service, and the Royal Air Force: each year Colleges admit junior Officers from these Services, who are sent to Cambridge to complete their training, and remain in residence two years as undergraduates. Another break with the past is the enormous increase in the number of young graduates who leave Cambridge to fill business posts: some are chosen primarily because of their knowledge of Chemistry, Geology, or other subjects, but not a few are selected because it has been found by experience that men brought up in the social atmosphere of College life have acquired qualities which fit them to be leaders of men.

Cambridge differs from the newer Universities in its wealth of traditions; it retains its love of ceremonial, and jealously adheres to many customs inherited from the Middle Ages; it also prides itself on the fact that, side by side with a reverence for all that is best in its inheritance, it is determined, not only to retain its reputation as a centre of sound education in the most liberal sense, but to spare no pains in keeping in the forefront of progress towards the ideal of fitting its students to take their place in the world as scholars, administrators, men of business, and gentlemen. It is only fair to add that much of the progress during the last twenty or thirty years has been made possible by liberal bequests and benefactions, which bear striking testimony to the high estimation in which the University is held as a progressive institution. The University is justly proud of the expansion and greatly increased attractiveness of the Fitzwilliam Museum which is due to the stimulating personality and untiring efforts of the present Director, through whom munificent benefactions have been obtained.

What can be said about the present-day undergraduates? Those who know them best believe that the average student takes his work more seriously than the average man of pre-war days. Slackers are comparatively rare, and their residence is usually curtailed: this is due not only to the fact that applications for admission are greatly in excess of the capacity of the Colleges, but it is largely the result of a saner outlook on life reflected in a greater keenness in work and a more pronounced sense of responsibility.

Though the great majority of students take an Honours Examination, there are some who from the first, or from force of circumstances at a later stage,

prefer or are compelled to prepare for an Ordinary Degree. One notable reform of recent years is the abolition of the old examinations for the Ordinary B.A. Degree, which were ill adapted for awakening intellectual interests, and the substitution of a comprehensive range of subjects much more likely to make an appeal to the imagination and to lead to a desire to adopt one of other or them as a hobby in after life.

There are few places in the world where as much provision is made for the student who desires to become a man in the fullest sense; he has within his reach a high standard of instruction in the subjects of his choice, exceptional opportunities for social intercourse in College life and in University societies, of attending occasional lectures on every conceivable subject, and access in the Fitzwilliam Museum, in the Museums of Ethnology and Anthropology, and in the Museum of Classical Archaeology to collections which he may study either for examination purposes or as a recreation and spiritual stimulus.

The criticism is occasionally made by visitors from other Universities that the disciplinary restrictions are irksome and out-of-date: this is not the view of the great majority of those who can speak from experience. There are regulations to be observed, and at times evaded; but there is an atmosphere of freedom which plays no inconsiderable part in the educational scheme.

Memories.

What, in a word, are the characteristics of Cambridge men? The answer to this question must be left for others to supply. A student comes to the University as a boy straight from school; as an undergraduate he becomes a man, and as a graduate of maturer years he retains vivid memories of associations and friendships of his undergraduate days which relieve periods of sadness or misfortune, and keep alive a sympathetic attitude towards those who are still young in years.

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Railway Progress in France and Belgium.

By Lord Monkswell.

Important improvements in the design of engines and signals have been recently introduced on the Paris-Brussels line. These are described by Lord Monkswell, who introduces some interesting comparisons.

FOR some time past the Pullman train, "l'Etoile du Nord," has been covering the $192\frac{1}{2}$ miles between Paris and Brussels in $3\frac{1}{2}$ hours without a stop. I have lately been privileged to make this journey in both directions on the footplates of the engines.

The line, which passes Creil, S. Quentin, Aulnoye, Mons and Braine, is one with varying features. On leaving Paris at S. Denis there is an ascent averaging 1 in 230 for some twelve miles to a summit near Survilliers, and then a similar fall to Creil. The next fifty miles to Tergnier are almost level. There is a summit between Tergnier and S. Quentin (95 miles from Paris) and, soon after, a nine mile climb, mostly at 1 in 200, to

an undulating table-land which extends as far as the Belgian frontier—crossed at kilometre post 233 (145 miles from Paris). From the frontier there is ten miles' steep fall into Mons. This latter piece of line belongs to the Nord-Belge Company, a subsidiary of the Chemin de fer du Nord, and is laid and equipped in the same way as the Nord. From Mons onwards the line belongs to the Belgian Railway Company, to whom the whole of the lines formerly worked by the State have been handed over. There are a good many speed restrictions in Belgium and near Braine there is a single-line tunnel which causes a delay of several minutes. Where no special speed restrictions exist speeds up to 120 kilometres ($74\frac{1}{2}$ miles) per hour are permitted in both France and Belgium.

The engines used are the well-known four-cylinder compound engines of the Nord. Originally introduced forty years ago these engines have been continuously developed and improved. The latest type, which now work most of the best trains, did not make their

appearance till some years after the war. They have six-coupled driving wheels, a leading bogie and a small pair of carrying wheels under the footplate. Like all engines of modern design they are fitted with super-heaters, which first dry and then greatly increase the

volume of the steam as it passes from the boiler to the cylinders. They have lately also been fitted with feed-water heaters, by which the feed-water is heated, sometimes actually above 212° F., by means of exhaust steam, the heat in which would otherwise have gone to waste. The drums on either side of the chimney are part of this apparatus.

Four-cylinder engines of this type lend themselves to far better balancing than is the case with two- or three-cylinder machines. The pistons and other parts which have a backwards-and-forwards, as opposed to a revolving, motion, can in four-cylinder engines be arranged to balance one another so nearly that for this purpose revolving weights may be either completely dispensed with or reduced to very small proportions, as the designer may think fit. This means that the variation in the stress imposed upon the rail by the balance weights during a single revolution of the driving and coupled wheels may either be eliminated altogether or else greatly reduced.

The importance of this matter has lately been brought out very clearly by the report of the Bridge Stress Committee appointed by the British Ministry of Transport. This Committee has investigated the stresses produced by all kinds of engines at different speeds, and the results have been published. It had for long been known that the stresses imposed upon the road by British engines were in many cases extremely high, but figures were seldom given. The



"L'ETOILE DU NORD."

One of the Pullman expresses operating between Paris and Brussels, which is worked by four cylinder engines that provide better balancing than other types.

report changes all that. As a striking example, two designs of engine may be set against one another. Certain three-cylinder engines of the L.M.S. are balanced in such a way that at 90 m.p.h. the weight on each driving wheel is reduced to nothing at one point of its revolution and consequently doubled at the opposite point— 180° away. With certain four-cylinder engines of the same railway, on the other hand, the weight remains constant whatever the speed. The value of four-cylinder engines in reducing the stresses to which the roads, and particularly the bridges, are subjected is therefore apparent.

These 4.6.2 Nord engines weigh, in working order, 96 tons, and are accompanied by tenders, running on two four-wheel bogies, weighing 75 tons. The tenders carry 37 tons of water, and in almost all cases render stops for water unnecessary over the whole of the Nord main lines. The only Nord express train that now stops, specifically to take water, is the Blue Train, which in winter takes passengers from Calais to the South of France and elsewhere. This train, timed at about 58 m.p.h. between stops, and frequently making up time with more than 600 tons behind the tender, might in certain circumstances not have water enough to run non-stop from Calais to Paris, and is therefore stopped at Amiens.

On the day I made my journeys the engine which worked the train from Paris was No. 3.1201—the initial “3” refers to the number of coupled axles. The train was composed of ten vehicles and weighed 494 tons behind the tender. The day was brilliantly fine.

From the Gare du Nord the line falls and provides a very easy start, but unfortunately there is a slight speed restriction at S. Denis so that the bank which extends from that station to the Survilliers summit cannot be approached with quite so much impetus as would otherwise be possible. Nevertheless, the whole twelve miles of the bank are frequently climbed at a speed averaging 60 m.p.h. or so and, though our load was on the heavy side, to-day proved to be no exception to this rule. The average speed was just under 61 m.p.h., and this was maintained right up to the summit. To achieve this it was, of course, necessary for the engine to work hard. With the full

pressure of 227 lb. per sq. in. in the boiler and the regulator wide open, steam was admitted into the high-pressure cylinders for 50, or even 55 per cent of the stroke of the piston. The horse-power developed against gravity alone was in the region of 1,100. The total horse-power must have been at least twice this latter—probably it was a good deal more than twice. In the cab there are numerous gauges which show the pressures in the high-pressure and low-pressure steam chests, the temperature of the superheated steam and other details, so that it is easy to see exactly what is going on.

On the descent to Creil we were delayed and lost three minutes, but then, after branching off from the Amiens line, we reached a speed of 70 m.p.h. on the level. Another slight slack soon followed, but after that 70 m.p.h. was kept up for thirty miles till, just before Tergnier, there was another slack for a bridge that was under repair. All these delays, which together amounted to the loss of five minutes, did not prevent us from passing S. Quentin in exactly the booked time of 93 minutes. For a long way beyond S. Quentin the difficulty was to avoid getting ahead of time. At Mons we were sent through the goods sidings, naturally at very low speed, a few miles further on a signal dropped only just in time for us to avoid a dead stop, and in the single-line tunnel beyond Braine repairs

were proceeding that obliged us to pass through at 6 m.p.h. Having by now lost nearly a quarter of an hour by delays, without counting our deliberately slow running before Mons, we were getting behind time, and, having reached a stretch of line suitable for high speed we ran for some distance at 70 m.p.h. At kilometre 16 from Brussels (10 miles) we still had more than ten minutes left and as the line is downhill we could have arrived punctually if we had had a clear road. It was not to be. We were dogged by misfortune. Slack followed slack. But we arrived only nine minutes late, though the delays which we had suffered amounted to well over twenty minutes.

For the return journey we had engine No. 3.1231 and a train of the same composition and almost exactly the same weight as before. Delayed by an adverse signal a few miles out of Brussels and by



NEW TYPE OF SIGNAL.

Lately adopted on the Nord lines, this signal comprises a row of lights (white or green) which it is almost impossible for the engine driver to miss.

another tunnel, but soon up a gradient some m.

A slack preparation begins on the French gradient places a bit is on the bank of 1 in $\frac{3}{4}$ mile wide open the high and late stroke, and high chests and 57° about 45° bank, for at the 45 m.p.h. summit ascent v.

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another very slow passage through the single-line tunnel, we took 33½ minutes to run the first 20 miles; but soon after this speed had reached fully 64 m.p.h. up a gradient of 1 in 250, and when the succeeding descent was reached it exceeded 74 m.p.h. for some miles.

A slack to 25 m.p.h. through Mons is a bad preparation for the ascent of the steep bank which begins a mile from Mons and continues right up to the French frontier. For more than nine miles the gradients average 1 in 125 but in places are much steeper. The worst bit is met with near the bottom of the bank and consists of 1½ miles of 1 in 82 immediately followed by ¾ mile of 1 in 95. With the regulator wide open and steam admitted into the high-pressure cylinders for 55, and later for 60 per cent of the stroke, the pressures in the boiler and high- and low-pressure valve-chests were respectively 227, 200 and 57 lb. per sq. in. Speed was about 40 m.p.h. at the foot of the bank, fell to a minimum of 33 m.p.h. at the end of the 1 in 95, rose to 45 m.p.h., and was 40½ m.p.h. at the summit. The average for the whole ascent was 40 m.p.h.

Once over the frontier we were again faced with the difficulty of filling up the time and, though when we passed Creil we had suffered extraordinary delays amounting to fully twelve minutes in all, we still had thirty-four minutes left for the final 31 miles. The first half of the ascent to Survilliers summit where the gradients are similar to those on the further side, had been completed at 60 m.p.h. when we were again overtaken by misfortune in the shape of a long series of slacks due to adverse signals, which made us five minutes late into Paris. But the delays we had encountered amounted to a quarter of an hour, and we had also had to reduce speed for some distance when we were before time.

In either direction we had used 32 tons of water, which corresponds to the consumption of four tons of good coal. (It was not possible directly to measure the coal used.) A small lesson in railway economics may be pointed. Four tons of good coal cost approximately £4. A 500-ton train will easily earn £400 in fares over the same distance.

There are considerable differences between the signals employed on the Nord line and those in use on the Belgian Railway.

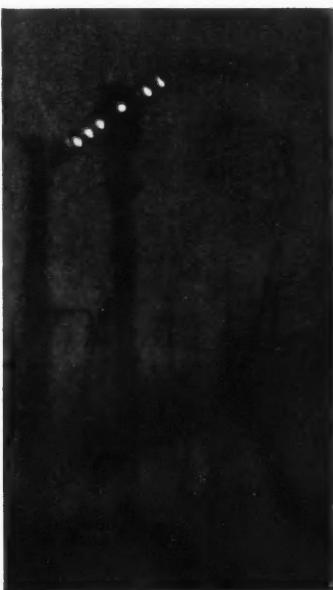
In France various forms of signal are in general use, which, when displayed, instruct the driver to stop or prepare to stop either at the signal itself or at some point further on. When the line is clear these signals, if discs or squares, are turned end-on to the approaching train; if semaphores, are lowered into line with the signal post. In either case they are

"effaced." By night various coloured lights are used for the "danger" indication, but "line-clear" is in all cases shown by a single white light.

It has lately been recognized that, on important main lines at least, some more distinctive indication might with advantage be given. So on the Nord main line new distant signals have been introduced. These are semaphores of a new type, which, like the ordinary British distant signals, give two positive indications—horizontal for "danger," inclined for "line clear." These semaphores, unlike those used in Great Britain, are illuminated by night by a row of lights along their whole length. When in the horizontal ("danger") position these lights are green; otherwise they are white. It was dark for some time before the return train reached Paris, and I had an opportunity of convincing myself of the extraordinarily good visibility of this type of signal.

In Belgium the signals are semaphores of a pattern generally similar to that used in Great Britain. For most of the way these semaphores are arranged as "three-position" signals—horizontal for "danger," inclined upwards for "one section clear ahead," and vertical for "two sections clear ahead." This arrangement is a valuable help for reducing the length of the block sections on very crowded parts of the line. A number of white-washed planks fixed to upright posts give warning that a signal is being approached.

My most sincere thanks are due to Monsieur Collin, Chief Mechanical Engineer of the Chemin de fer du Nord, for allowing me to make these journeys and for the excellent photographs of the Nord distant signals; and to Monsieur Rulot, Manager of the Belgian Railways, who also authorized me to travel.



THE SIGNAL AT NIGHT.

The row of lights stand out conspicuously in the darkness and afford a great improvement on the single lamp at present generally in use elsewhere.

Solders used by the Goldsmiths of Ur.

By Ernest A. Smith, A.R.S.M., M.Inst.M.

Having examined some of the gold objects recently discovered in Mesopotamia, the author is able to reveal new details of the soldering methods employed six thousand years ago. The remarkable knowledge of the ancient craftsmen becomes clear from comparison with present-day practice.

THE successful excavations at Ur of the Chaldees, made during recent years by Mr. Woolley, have brought to light many beautiful examples of ancient goldsmiths' work, which clearly show the high degree of technical manipulation attained over five thousand years ago. The latest finds take us back to a period before the first dynasty, which we now know to have been preceded by a line of kings and queens hitherto unknown, and their exquisite craftsmanship must have been the heritage of many centuries of culture. Amongst the questions of archaeological and scientific interest which these discoveries raise, that of the method of soldering used is by no means the least important. The problem as to when, where, and how the use of solders originated has yet to be solved, but the discovery of soldered joints on objects from Ur proves that their employment goes back to a period far behind the first dynasty.

The introduction of soldering unquestionably marked a very notable step forward in the development of the goldsmiths' art. The necessity for some method of satisfactorily uniting two or more pieces of metal must have been felt as soon as the craftsman became more skilled in his work, and began to depart from the simple designs with which we are familiar in the primitive gold objects of all nations. During the last few decades much useful information on the early use of solders has been accumulated, and more or less definite conclusions have been drawn. Additional evidence, however, is needed, and in the present article are included the author's conclusions, based on a careful examination of some small objects from Ur which were kindly placed at his disposal by Mr. James R. Ogden, of Harrogate, who has visited the excavations.

A Queen's Necklace.

These objects, which came from the grave of Queen Shubad, consisted of eight small hollow gold beads which formed part of a necklace, and were probably threaded alternately with similar beads of lapis lazuli. All the beads were about three-eighths of an inch or less in length, four being in the form of two cones base to base made of sheet gold, and soldered

longitudinally, whilst the other four beads were barrel-shaped and slightly smaller than the conical beads, but all had longitudinal soldered seams. In addition, there were two pieces of granulated gold decoration consisting of six very small grains joined together to form a ring, and five grains joined together and appeared to have formed part of a larger ring. These objects were accompanied by small pieces of gold foil, a semi-fused hollow gold bead (evidently an accident in soldering) and several lapis lazuli objects. Although somewhat small, all the gold objects were sufficiently large and representative to afford reliable information as to the methods of soldering, and were examined chiefly in relation to this question.

Typical Analyses.

From the few analyses so far made in the British Museum Laboratory, the gold objects appear to be about eighteen carat quality, *i.e.*, 75 per cent pure gold. Two of the gold beakers from Ur gave the following analyses* :—

	FLUTED BEAKER.	PLAIN BEAKER.
Gold 73.48 per cent	75.62 per cent
Silver 24.73 "	23.34 "
Copper 1.79 "	1.04 "

The gold content is somewhat below the average for native gold, but it is very difficult to draw conclusions as to the source of the gold from the analyses of ancient objects. It is not improbable that native golds from different sources were melted together, thus removing the possibility of determining the source of any particular sample. It is also very probable that damaged and obsolete articles of jewellery were remelted with native gold, with the very possible contamination of solder, and also of copper which was frequently used as a backing or strengthener for objects made of thin sheet gold, and may not in all cases have been satisfactorily removed before melting took place. The analyses do, however, give some indication of the quality of the gold upon which soldering had to be done.

With about 25 per cent of silver, the beautiful characteristic yellow colour of gold in the alloy assumes

**British Museum Quarterly*, 1928, p. 85.

a pleasing greenish-yellow tint, which has caused it in modern times to be designated green gold. The rich yellow colour of pure gold is not materially affected by alloying with moderate quantities of silver, so that the jewellery made of gold-silver alloys above about eighteen carat quality (*i.e.*, 75 per cent gold) would still possess a rich yellow tint and a beauty of surface which give a special charm to the personal ornaments made of them. All the gold beads from Ur examined by the author were of a rich yellow colour, with one exception, which was a slightly paler yellow and evidently contained more silver. The whitening effect of silver on gold may be counteracted by the addition of copper, and it would appear that the early Egyptian goldsmiths were to a certain extent familiar with this fact, as the analyses of ancient articles of good gold colour recorded by Williams and others have shown the presence of copper and silver with a gold content as low as 42 per cent in some cases.

Soldered Rings.

In this connexion Sir Flinders Petrie states that "base gold was much used in Egypt at the close of the eighteenth dynasty, and many of the finger rings of that age almost verge into copper." ("Arts and Crafts of Ancient Egypt," page 94.) The presence of copper increases the difficulty of soldering and necessitates the use of a flux to remove the copper oxide that forms on the surface during the operation. Borax, the universal flux of the goldsmith, was well known to the Egyptians, and Schlieman states that it was used by Mycenean goldsmiths for soldering gold. Sir Flinders Petrie has frequently drawn attention to the delicacy of the soldering on Egyptian gold, jewellery, etc., of the first dynasty, which was done without leaving the least excess of solder, or difference of colour at the joint. More recently Mr. Woolley has made reference to the general use of solder at Ur before the first dynasty, in a letter to Mr. James Ogden, in which he wrote:—"At that period the Sumerian goldsmiths were quite familiar with gold solder, and we have numerous examples of it. Thus a finger ring would be made with a length of gold wire square in section, one end of this would be bent round into a hoop, then a section of the wire would be twisted and bent to make three hoops, and the last section left plain would make a fifth hoop. Then the five coils would be soldered together on the inside of the spiral, and the effect was obtained of a ring with plain edges and a centre formed of three bands of rope pattern."

The finger rings of elegant shape discovered by Mr. Woolley prove that soldering was practised nearly

six thousand years ago, and it is very evident that its use originated at a much earlier period although, as previously stated, we have no information as to its beginnings. It may be remarked here that soldering was an easier operation for the ancient craftsman than it is for the modern goldsmith, inasmuch as the gold used in ancient times consisted of native gold, composed of gold and more or less silver, which does not oxidize or tarnish when heated or melted, whereas the gold solder alloys used in modern goldsmith's work almost invariably contain copper and very frequently zinc. Both of these metals are oxidizable and give rise to a film or scum of oxide that has to be removed by means of a flux in all soldering operations.

The published data hitherto available on ancient solders, and the methods of using them, have been well summarized by C. R. Williams in his introduction to the catalogue of Egyptian antiquities in the collection of the New York Historical Society, published in New York in 1924. From this summary it is evident that three distinct methods of joining gold call for consideration, *viz.* :—(1) Fusion or sweating in which the pieces are joined by the local fusion of the surfaces when in close contact. In modern practice this method is designated "auto-generative" soldering, and is used for uniting lead, and for other metals; (2) Soldering with the aid of a solder consisting of a piece of the same metal as that composing the object to be soldered; (3) Soldering with the aid of alloys (*i.e.*, gold and silver) having a lower melting point than that of the metals to be joined. In the author's opinion there are indications that all three of these methods of soldering gold were in use in ancient times, and this opinion has been confirmed by the examination of the objects from Ur.

The Fusion Method.

To effect a satisfactory joining by the fusion method skilful control of the blowpipe flame is absolutely necessary, as a slight excess of heat, or too large a flame, would result in the partial or even complete fusion of the object on which the joint was being fused. It is now well known that the Egyptian, and other ancient goldsmiths, possessed the requisite skill in the use of the mouth blowpipe, which usually consisted of a carefully selected reed thinly coated with clay to protect it from burning as far as possible. There is little doubt that this important adhesive property of gold when suitably heated had been observed by the ancient goldsmiths, and that they possessed the necessary skill to turn it to practical use. The employment of this fusion method of uniting two pieces of gold is well exemplified in the delicate joints

seen on the so-called granulated or shot-work jewellery, which is such a special feature of Egyptian goldsmiths' work of the twelfth dynasty, both for main and for subsidiary decoration. The solid gold balls or grains on this class of work are very minute, and are frequently not more than one-fiftieth of an inch in diameter with a joint between two grains of less than half this measurement. All those who have examined samples of ancient granulated work have been very impressed with the very fine nature of the joints, and the extreme delicacy with which the joining has been effected. The probable method of manufacture of these minute grains is discussed by Williams. The author's examination of the small representative samples of granulated work from Ur led to the conclusion that the fusion method had been used in joining them together and that no special solder had been used. Under the microscope at magnifications of about 15 and 30 diameters, they gave every indication, from the appearance of the joint between the grains, and the absence of any excess solder, that this method had been used.

General Conclusions.

With the evidence now available it may generally be concluded that delicate joints, *i.e.*, showing no excess of solder, and uniform in colour with the gold object, have been effected by the fusion method, whilst thicker joints, frequently of a slightly paler colour, have been soldered either with the same metal as the object, or with an alloy of lower melting point. In the absence of any difference of colour, careful examination under the microscope will in most cases enable one to distinguish between a fused and a soldered joint. Unfortunately the rarity of ancient gold objects, and the minute quantity of solder in a seam, or joint, make it impossible to obtain sufficient metal on which to make an accurate analysis. In modern goldsmiths' work the composition of the solders is usually so arranged by the addition of silver, copper and zinc to the gold, that it has the same colour as the gold to be soldered, but ancient solders are invariably alloys of gold and silver, and in consequence are paler than the gold on which they are used. Whatever method was employed to affix the minute grains, whether fusion or soldering, there is little doubt that some kind of adhesive matter, such as tragacanth gum, was necessary to hold them in position until a metallic union could be effected.

Turning now to the question of the composition of the ancient solders, an examination of the joints on some objects of the goldsmiths' craft leaves no doubt

that they have been effected by solders as distinct from the fusion of the surfaces in contact. The hollow gold beads from Ur showed clearly that solder had been used in their make-up. A partly broken seam of one of the cone-shaped beads gave undoubted indication that it had been soldered with gold of the same colour and quality as the bead itself. Under the microscope at 15 and 30 diameters the seam was very distinct and wider than the delicate seams on granulated work, and showed the crystalline structure of a fused metal. It had all the appearance of a soldered joint as distinct from a fused joint, and being of the same colour as the bead itself led to the conclusion that the same quality gold had been used as a solder.

The seams on several of the other large beads examined confirmed this conclusion. The fact that the soldered seams in ancient work are very frequently the same colour as the gold objects on which they appear has led to the suggestion that a gold-silver alloy of lower melting point has been used, and that the whole object when finished has been subjected to some pickling operation in acid reagent whereby the silver has been dissolved out on the surface of the soldered joint, thus imparting to it a golden colour. If pickling or some such process were adopted the gold colour of the seam would be superficial only, and could easily be removed by scraping, thus revealing the true colour of the solder alloy. Experiment shows, however, that the colour of the seams in ancient gold work remains constant even after the solder has been sufficiently scraped to remove any superficial colouring. Methods of colouring gold alloys were in use at a very early period, but at present we have no data as to when and where they were first introduced.

A Gold-Silver Alloy.

The use of a solder consisting of a gold-silver alloy of lower melting point than the gold on which it was used was very clearly demonstrated on two of the cone-shaped beads from Ur. The longitudinal seams were silver white in colour, and were very distinct. Examination under the microscope clearly showed that in one case the seam had been scraped to remove excess of solder. The other bead showed a number of white spots apart from the seam, which varied in size and had the appearance of small splashes of solder, and were evidently the result of careless work. These spots were very carefully examined, as it was at first thought that they might be due to small particles of platiniferous material that had been melted with the grains of native gold, and had revealed their

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presence when the melted gold was hammered out into a thin sheet for the goldsmiths' use. Their appearance under the microscope, however, showed that they were undoubtedly splashes of solder. Obviously it was not possible to determine the composition of this white solder, but from the fact that it had not tarnished, but had retained a bright silver white appearance, it must be concluded that it consisted of a gold-silver alloy containing at least 40 per cent of silver. A spot of chromic acid when placed on the seam failed to produce any discolouration.

The discovery of these beads soldered with a different gold alloy of lower melting point is extremely interesting as showing the very early use of distinct alloys for soldering purposes. The solders used may have consisted of native gold from a different locality and known from experience and observation to melt a little more readily than native gold from other sources, or the alloys may have been especially prepared by mixing definite quantities of silver with the native gold. The form in which the solder would be used was probably the same as that in use at the present time, and consisted either of narrow strips or small pieces of hammered sheet gold, or of dust or powder which could be obtained in almost any degree of smallness from the usual gold washing operations employed for its extraction.



HAILSTONES AT PRETORIA, 1923 (MATCHBOX SIZE).

Correspondence.

THE FORMATION OF HAIL.

To the *Editor of Discovery*.

SIR,

In the September number of *Discovery* appeared a most interesting article on the formation of hail by Dr. C. E. P. Brooks. I thought a few remarks on the terrific hail-storms in this country might be of interest, but unfortunately have been delayed in writing by a search for suitable photographs to illustrate my points. I enclose a couple, however, which I obtained from Messrs. Fenners' Photographic Stores, Pretoria. These are of hail-stones collected after the famous storm on the late afternoon of Christmas Day, 1923, and are typical. We ourselves collected two fairly large kitchen bowls heaped with similar stones from a few yards square of my garden. There were two distinct types, one being like that shown in Fig. 1 of the article, and ranging from, I should say, $\frac{1}{2}$ inch to $1\frac{1}{2}$ inches in diameter; the other and larger class consisted of irregularly shaped masses of stones frozen into absolutely solid masses. The component stones of this latter class were pretty well opaque, about $\frac{1}{2}$ inch to $\frac{3}{4}$ inch diameter, frozen solid into lumps, many of which were considerably bigger than tennis balls.

Dr. Brooks says that it is hardly probable that freezing together occurs before falling, and that it most likely takes place on the ground. In this particular storm I was told of huge masses falling and breaking to pieces as they struck the ground, but I saw very few break even when falling on the paths, and I myself picked up stones of the composite type as they fell and bounced toward my verandah. There cannot be the slightest doubt that not only did the freezing take place before the fall, but that it was a most thorough, widespread and effective freezing. Another interesting feature was the existence of isolated stones of the single type with a distinct flattening, coming very near to the apple shape referred to by Dr. Brooks. These, however, I noticed only after the storm when examining the hail. It is therefore conceivable that there may have been a slight melting at the point of contact with the warm earth as it had been a very hot day.

It may be of interest to add that all tiled roofs in the path of the storm were cut to pieces. The average bill for repairs in the case of small houses was from £100 to £300. At the Transvaal University College, of which I was at that time Registrar, it cost us over £3,000.

Yours faithfully,

A. A. ROBERTS.

8 Tudor Buildings,
Pretoria, 12th November, 1929.

Dr. C. E. P. Brooks writes:—

"Mr. Roberts' letter is of great interest. The Christmas Day hail-storm of 1923 in Pretoria has become almost historical. I am glad to have his precise observation that hail-stones actually fell frozen together. As a rule the stones are not examined until the storm is over—for obvious reasons—and in those cases it is impossible to say where the aggregates were formed. My reason for saying that freezing in the air is not probable was that the outermost layer of a large spherical hail-stone must be formed at a comparatively low level from the freezing of water at 32° Fahrenheit, and therefore comparatively slowly. The stones being at the time in rapid motion will seldom remain in contact long enough to freeze together, but Mr. Roberts' observation shows this can sometimes happen."

Training a River.

By J. H. Dunbar, B.Sc.

Engineer in the Sudan Government Service.

In order to facilitate navigation in shallower parts of the Nile during the annual floods, a simple method has been evolved by which the river is made to maintain and deepen its channel. The problem applies to the section of about one hundred miles between Assuan and Wadi Halfa.

Most of the problems of the Nile, which deal with the conservation and distribution of the flood, are the same to-day as they were when the world was young, for such modern engineering triumphs as the dams at Assuan and Sennar are but elaborations of the earthworks built in the same regions and for the same purpose by prehistoric man. Five thousand years ago the ancient Egyptians built stone "Nilometers" from which were read the height of the river. Since those remote times such readings have been regularly recorded and, incredible as it may seem, some of the original Nilometers, or as they are now called, Nile gauges, are similarly employed to the present day. Surely there can be nothing else in history that boasts such long and unbroken continuity!

An Important Problem.

In recent years there has arisen a new problem, with the study of which this article is concerned, though there is the possibility, as we shall see presently, that even this is but another confirmation of the dictum that there is nothing new under the sun. The journey from Egypt to the Sudan is accomplished partly by railway and partly on the river, the train running from the coast at Alexandria or Port Said to the first cataract at Assuan, where it connects with the river steamer that operates as far as the second cataract at Wadi Halfa—the terminus of the Sudan railway. It is to the part of the journey made by water, or more exactly, to the southern half of it, that our attention is now turned.

When it is mentioned that these river steamers, each of which may tow a hundred-foot barge lashed on either side, are modern craft carrying a hundred and fifty passengers, together with mails which demand that they must run to a strict and express time-table, it will be realized that the question of all-the-year-round navigation is a most important one, and, depending as it does on so many variable factors, this is not at all a simple matter.

It may seem at first sight strange that there should

be any great difficulty in navigating a mighty river like the Nile that is in parts a mile wide, but when it is realized that at high Nile during the flood—which reaches a maximum in September or October—there is a depth of thirty feet of water which falls at low Nile in April or May to a comparative trickle two feet or so deep, it will be appreciated that there are many obstacles in the way of keeping open a regular service, even for the most shallow draught steamers. Paradoxical as it may sound, a year of good flood is not necessarily the best from a point of view of navigation, in fact more often than not a moderate flood is much more suitable, for a good flood—though a boon to the irrigation department and landholders in that it brings down more water—also means a wide shallow river, which for steamers is not nearly so desirable as a deeper though narrower channel.

Navigation depends naturally in the first instance upon the amount of water in the river, which is more or less according to the rainfall at its sources in Central Africa. This water is controlled by the dams, which hold up or release it purely from considerations of agriculture, and which thus influence the depth of water and strength of current quite regardless of steamers' requirements. Thirdly, there is the caprice of the river itself, the most difficult factor of all to gauge, but upon the understanding and anticipation of which river-training work so largely depends.

Rocks and Sandbanks.

As the river subsides after the flood its surface is broken by innumerable rocks and sandbanks, and what was previously a wide unbroken expanse of water becomes a complicated network of channels and islands. It is no exaggeration to say that during the critical period of receding flood every single yard of the affected reach is constantly sounded, for though the rocks are fixed obstructions whose positions can be accurately charted and buoyed, the same cannot be said of the sand and mud banks, as the vagaries of the river and silt-depositing action are such that the channels are rarely identical in successive years and the steamer

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track has to be mapped out afresh after every flood season. As the length of river involved is over a hundred miles, the possibility of blasting a way through the rocks is out of the question, and the problem resolves itself into discovering and keeping open a route through such courses as flow over sand and mud.

The first and perhaps most obvious solution that suggested itself was to cut a channel by dredging, but to this there was the very serious objection of the prohibitive initial cost of expensive machinery, together with the annual provision both in time and money that would have to be made, in view of the necessity of dredging a new channel every year, the gravity of the situation being increased by the fact that when passenger traffic on the reach was at its height the state of the river was at its worst.

The possibility was next considered of so restricting the width of the river that the same volume of water would have to flow through a narrower channel and would so make such a limited channel deeper, and it is from this principle—after many trials and experiments—that the present practice has been evolved. If obstructions are so placed in a river as

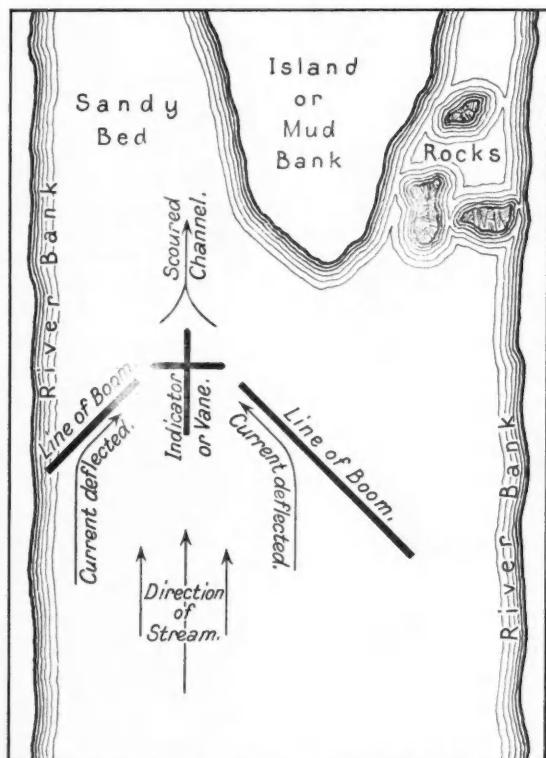


DIAGRAM SHOWING HOW THE BOOMS ARE PLACED.



PREPARING THE BOOMS.

Modern practice is to use wire-netting in the construction of the booms, which must not too greatly obstruct the flow of the river.

to diminish its width, it is clear that the same amount of water, having to pass through a smaller space, must flow with increased velocity, and this increased velocity so acts upon the sandy bed of the river as to scour out a channel sufficiently deep to render navigation not only possible but safe.

The first artificial obstructions to be placed in the river were wooden boats, so heavily laden with sand that they grounded on the bed, and later on—as an elaboration of this—steel barges becoming available were flooded with water and similarly sunk. The objections on the grounds of cost to this procedure are obvious, and though the success of the experiment was but moderate, it was seen, nevertheless, that the principle was sound, and, if financial and other difficulties could be overcome, possessed decided possibilities.

The next development was the construction of flexible booms which, compared with stranded barges, had the advantages of being cheaply made and easily transported, and the further recommendation of being quickly lowered in the river and picked up again as required. The first booms were—in the light of present knowledge—primitive affairs of trees and branches, fastened together in a continuous line, and anchored in the river; next were tried booms made of a local native palm matting, something like coconut matting, fixed to floats in the form of wooden poles at the top and to sinkers of scrap iron at the bottom. From these evolved a boom made of wire netting which was from the first wonderfully successful, and is now employed in large quantities as standard practice and annual routine of river-training.

Countless experiments have shown that to function satisfactorily a boom must obstruct the river just sufficiently, neither more nor less, and to give the best results should be laid at an angle of forty-five degrees to the stream. If the boom is too coarse, as in the

case of large-mesh wire netting, the water merely flows through it, while if it is too fine—as with palm matting—the obstruction offered is so great that either the boom is swept away, or compels the river to change its course without scouring out a deep channel. A compromise is effected and the ideal boom produced by inter-weaving wire netting with native palm rope, though all booms are not the same—the density of the boom or the amount of rope interwoven depending on the strength of the current. The slower the stream the more dense is the boom required.

Time and Current.

Having designed a suitable boom there are still other factors to be taken into consideration. It is clear that a boom can only operate when there is a current flowing, which is only the case when the dam is open, for when the dam is closed the river becomes to all intents and purposes a lake, or inland sea. Again, the time factor is an important one, for though the booms, by constricting the course of the river, induce a scour, the action of the scour is slow, and it may take weeks, or even months, sufficiently to deepen a channel. The essentials, therefore, for successful river-training, are plenty of time and plenty of current, and to ensure both, river-training—to guarantee a continuous navigable channel in the bad months of April and May—is commenced in the previous December when the river is running strongly, though such an early start demands a life-time of local knowledge and rivercraft to anticipate the sandbanks and the best channels to boom.

Setting out on a river-charting and boom-laying voyage has some of the thrill associated with a polar expedition or a whaling excursion, for in December, even on the Nile, there are bitterly cold winds that blow up the surface of the river into white horses and stinging spray, and give all the impressions of putting out to sea.

The outfit consists of a small steamer, or tug, which is the temporary home of the officials, crew, and working party, and to which is lashed on one side a barge carrying the booms and buoys which have been previously made in the dockyard, while on the other side is similarly secured another barge fitted out with machinery for laying the booms. The booms are made by nailing the rope-interwoven wire netting already described to old telegraph poles at one end, and weighting with scrap railway line at the other, the booms being rolled up like umbrellas for transport and unfolded and let down like window blinds when in position for lowering. A boom may be any depth from five to eight feet, for working in more than eight

feet of water is very difficult, and experience has shown that it is quite early enough to commence boom-laying when the river has fallen to this level.

An interesting part of the equipment is an indicator or vane, in the form of a large wooden cross, for showing the direction of the current and giving the line of the boom. The indicator has three arms of equal length, the fourth arm being about twice as long as the others, and at the ends of the three short arms are fixed little flags. To the junction of the arms of the cross is attached an anchor so that when the indicator is thrown into the water it is free to take up any position, but cannot be carried away by the stream, just as a weathercock is free to turn on its pivot and yet cannot be blown away by the wind. It sets with its long arm up and down stream, showing exactly the direction of the current, while a sight taken over any two diagonal flags gives a line at an angle of forty-five degrees to the stream and consequently the line of the boom.

Arrived at the scene of operations, which is decided upon from the reports of pilots and engineers, to whom the state of the river is an almost hourly concern, the indicator is put into the water. A sight over the flags gives the direction of the boom, which is further marked by dropping buoys, and the two barges are securely moored in this line. Three booms at a time are lifted by derricks on the specially equipped barge, unrolled, firmly lashed together, and lowered over the side where they are weighted, dropped into the river, anchored, and buoyed. The barges are then warped further along the line, and the procedure repeated until sufficient booms have been laid, all the booms being joined to form a continuous and unbroken obstacle to the current. In this way both sides of the channel are boomed, the appearance when completed resembling that of a huge corral leading into a stockade.

Constant Patrol.

The importance and magnitude of the task may be gauged from the facts that at a bad spot in the river a double line over half-a-mile long may be laid, while during a season's working over the whole reach it may be necessary to put down several miles of booms to keep the channels open.

When the booms have been laid, two or three sailors are left behind on maintenance work, for it is essential that the booms should be constantly patrolled in a rowing boat to ensure that lashings and anchors are secure and that nothing breaks away, while at night they have to be lit up by hurricane lamps. This, as can well be imagined, is not a much-sought-after job, for it often means working for hours at a time in

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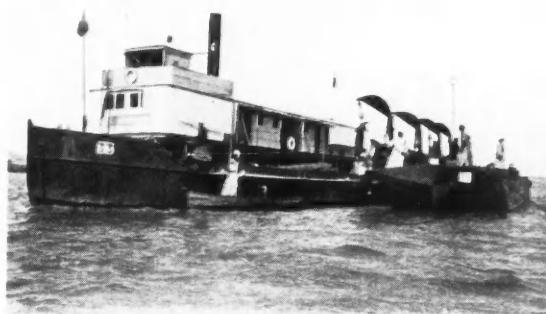
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the icy water, and the loneliness is comparable with that of lighthouse duty at home.

In practice this river-training has proved most successful in every way, and whereas only a few years ago, steamers grounded for hours on sand banks and had to be warped and even towed off, nowadays they experience no difficulty in running to time-table. It is practically ideal in that it is quick, cheap, and simple, for all the materials used are scrap, and, though occasionally a boom gets so silted up that it cannot be withdrawn and must be abandoned, nearly everything can be salved at the end of a season's working and used again the following year. The very fact that it does get so firmly embedded in several feet of sand and silt that it has caused to pile up, is clear proof that a boom does fulfil its functions and forms what is to all intents and purposes an artificial river bank within the limits of the natural bank.

Tribute must be paid to the intelligence and river-sense of the native pilots whose anticipation of bad places is almost uncanny, for it is on the information of these men that such early action can be taken as will ensure the successful working of the scheme.

River-training has been carried out in other parts of the world, notable in India, France, Mesopotamia, and on the Mississippi. In India such work would be described perhaps more correctly as estuary-training, consisting as it does of building stone groynes, retaining walls, breakwaters and such permanent obstructions as are associated with docks and harbours. In France, on the Loire, and in Mesopotamia, on the Tigris and Euphrates, attempts have been made at river-training on lines similar to the earlier experiments on the Nile, stakes and hurdles made of local reeds and rushes being driven into the beds of the rivers, but apparently the results were not so satisfactory as to encourage further research in this direction.



"THE OUTFIT."

Barges carrying derricks and booms are lashed to the small steamer, which forms the quarters of the engineering party.

On the Mississippi certain reaches are trained in a manner that approximates essentially to the practice followed on the Nile, though it would appear that on the American river the engineer is not so restricted by other considerations such as the limitations imposed by local irrigation requirements. The American method is to drive piles across the river at right angles to the current, leaving open only the channel that is to be navigated, the piles being so interlaced with willows as to form a solid obstruction, and this rigid boom being supplemented by a diagonal boom a little farther down stream from the opposite bank. This training is said to be very satisfactory, but the capricious Nile would not tolerate such drastic coercion, for though it will consent to being led, it refuses emphatically to be so curbed and driven.

On the reach of the Nile just described there are to be seen in many places rocky promontories stretching out from the banks into the river, like derelict piers. Viewed from the deck of a steamer these might be taken for natural obstructions, but a closer examination reveals that they are man-made jetties, being well and solidly constructed of hewn stone. Local tradition has it that they were built by the Romans, and there can be very little doubt that this explanation is not far from the truth, for as we know from ruins of bridges and aqueducts in Europe, the Romans, as hydraulic engineers, conceived and carried out works that are the admiration of the most eminent professional men to-day.

It is possible that these groynes were built out into the river to hold up the fertile Nile silt, and so increase the area of land available for cultivation, though it is quite as plausible that their purpose was to train the river, and that we are merely carrying a little stage further to-day ideas that were first put into practice two thousand years ago.



LOWERING THE BOOMS.

The booms are weighted and lowered from derricks over the side of the special barge. A continuous line half-a-mile long is sometimes laid.

Rhythms in Bird Behaviour.

By V. C. Wynne-Edwards, B.A.

Department of Zoology, Bristol University.

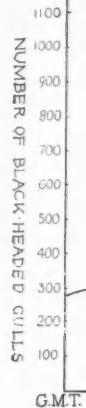
How far birds are "intelligent" is a subject that has long been the subject of controversy. New light on the problem is forthcoming from a study of some black-headed gulls observed near Plymouth by the writer, which supports the view that instinct and rhythm are the predominating factors governing bird behaviour.

BLACK-HEADED GULLS, spending the autumn and winter on the coast, will fly up an estuary to feed on the mud- or sand-flats exposed when the tide is out. They may travel as much as ten miles to and fro in a long estuary like that of the Tamar or Fal, but they always return to the open water for the night. They do this because, if they went to sleep on the fluctuating waters of the estuary, in the middle of the night they might find themselves aground, or swept against the piers of a bridge, against buoys or shipping. They go, therefore, to the sheltered waters of a bay where the tidal movement is small and constant vigilance is unnecessary.

Preliminary observations of this kind lead to the problem of how it is that birds are able to carry out this programme day after day, when the times of tides and of sunrise and sunset are always changing. The problem itself is very far from being solved, but by closer investigation of the habits of the birds very interesting facts are brought to light. From the beginning it is clear that there are two conflicting factors at work. The first one is only in force during the day. It makes the bird fly up the estuary on the ebb tide and back to the sea on the flood; it makes it seek food upstream on the mud-banks at low water and in the sea at other times. The second factor, which may be called the "day-night" factor, inhibits the tidal factor at night. The birds do not go to the mud-flats to feed in the dark because the tidal factor is not operating at that time. It is over-ruled by the second factor, which is also responsible for bringing the birds to their proper quarters in the evening. It may be objected that the movements of an intelligent bird are not regulated in this blind way by factors over which it has no control, but it must be remembered that to assume intelligent behaviour on no grounds whatever is a cardinal error, and does not lead anywhere.

In order to put this in a more concrete form, a piece

of estuary, near Plymouth, one hundred acres in extent, was marked out (Fig. 1) and the number of black-headed gulls in the area was counted every hour through the day on a number of occasions. It was necessary to choose both days of spring-tides, when the mud-flats were exposed in the middle of the day,* and days of neaps, when low water was at six in the morning and six at night, and the estuary remained an open sheet of water for the greater part of the day. The result of one of the spring-tide days in August is shown diagrammatically in Fig. 2. The thin undulating line shows the height of the tide at any



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For the his position birds in their feeding decided direction apart from was now soon after birds in alighted fields. the mud of almost channel. the mud into the and better feed until began. gulls high downwards observational graph strength and fifty

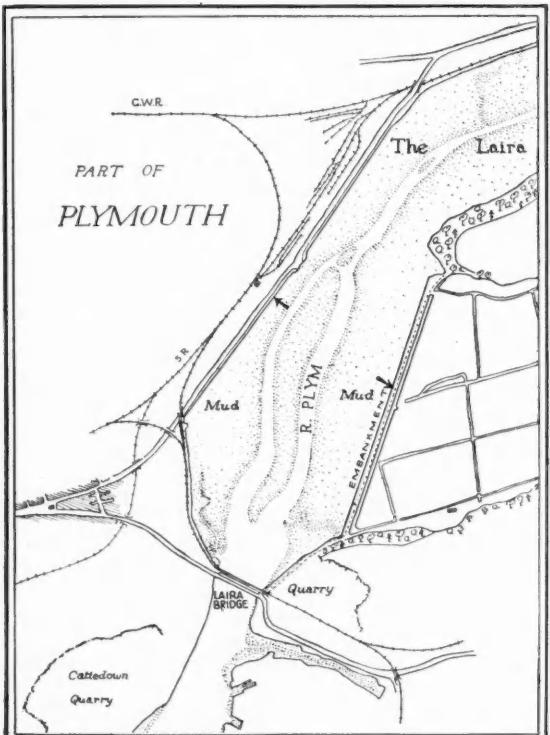


FIG. 1.
MAP ILLUSTRATING THE WRITER'S EXPERIMENT.
The approximate area observed is indicated by arrows

*At any place, high-water springs always occur at the same time of day. The same applies to any other state of homologous tides, i.e., L.W.S., H.W.N., etc.

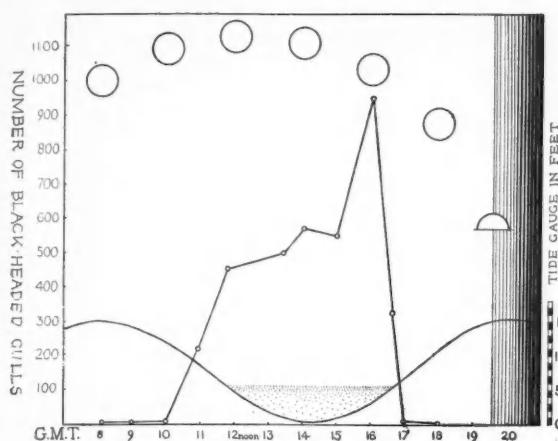


FIG. 2.
NUMBER OF GULLS IN RELATION TO TIME AND TIDE.
Details of this diagram are described in the text.

time (tide gauge on the right), and the hollow of the curve occupied by dots shows how long, and to what extent, the mud-flats were exposed. The altitude of the sun is shown by circles; twilight and darkness are represented by shading on the right. Lastly, the number of black-headed gulls in the area is shown by the thick line.

For two hours from the time the observer took up his position at 8 a.m. there was only a handful of birds in the area, sitting idle on the water or preening their feathers. Then just before 11 a.m. there was a decided movement of gulls into the area from the direction of the sea. The tide was still "in," and apart from a fringe of sea-weed on the shore there was nowhere to feed. The movement continued, and soon after 11 a.m. there were three or four hundred birds in the area. These birds circled around or alighted on the embankment wall or in the neighbouring fields. About noon the ebbing tide left the tops of the mud-banks, and in the next half-hour was clear of almost the whole area except for a wide central channel. Very quickly the waiting gulls settled on the mud and began to feed. The movement of birds into the area slowed down to practically nothing, and between five and six hundred birds continued to feed until about 3.30 p.m. Then the reverse process began. The flood-tide was coming up slowly, and gulls higher up the estuary started to work their way downwards. Enormous numbers stayed in the observation area for a last feed, and that is why the graph has a high peak at 4 p.m. With increasing strength the downward flight went on. Six hundred and fifty birds left the area between 4 and 4.30 p.m.,

and by 5 p.m. there were scarcely a dozen left. The area remained deserted until the observer came away.

There is nothing very extraordinary about this. The only point to notice is that some four hundred gulls had come up into the area before the mud-flats were exposed, to await the receding tide. They were on the spot ready to begin feeding at the first possible moment.

In Fig. 3 the results of a neap-tide day are similarly shown. The undulating tide-curve is much shallower, and the flats are exposed for a shorter time. At 9 a.m. when the observer took up his position there were eight hundred birds in the area. The tide was almost up to the shore, and the general downward movement was rapidly depleting the number. The circumstances were, in fact, just the same as at 4 p.m. on the day shown in Fig. 2. After 10 a.m. the observer went for a walk, but returned to the estuary twice during the next few hours, each time to find a few birds sitting doing nothing in particular on the water. This is represented by the broken part of the graph. At 5 p.m. he returned again and found nearly three hundred birds already in the area or waiting around. At 6 p.m. the tide was still in, and the number had risen to four hundred and forty. The mud began to appear between 6.30 and 7 p.m., and over eleven hundred birds had come up. Only a few fed—perhaps a hundred in all. Ten times as many settled in long lines on the shore and waited.

Just as the flats were becoming inviting the sun set. This is the interesting point. It quickly got darker, and between 7.15 and 8 p.m. every one of those eleven hundred gulls flew back to the sea. A few had fed for perhaps twenty minutes, but the vast majority had had no food at all. They had flown two miles

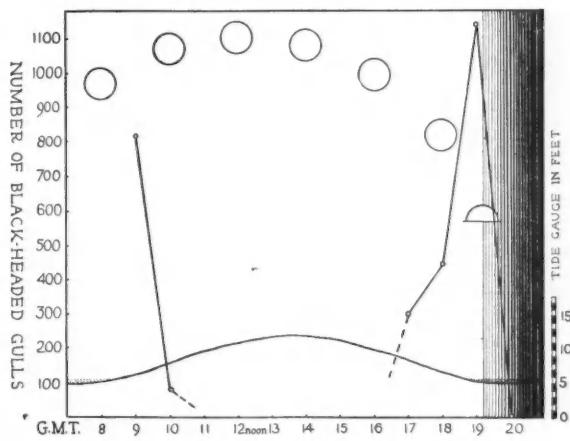


FIG. 3.
MORE OBSERVATIONS ON GULLS.

up from Plymouth Sound, and now two miles back, without having gained anything whatever.

It is very clear from this that the first idea of a day-night factor overruling a tidal factor was not mistaken. It is exactly what is found on investigation. As long as it was light the gulls were driven by the tidal factor to fly up to their feeding grounds. That the sun was already low in the sky when they started had nothing to do with it. Then, the moment a certain degree of darkness was reached, its whole effect was inhibited, and back they went to the sea without having fed.

Time and Tide.

Although this gives some insight into the control of the birds' movements, it tells nothing at all of how the controlling forces actually work in the mind of the bird. It is usual to "explain" facts of this kind by supposing the behaviour is due to some kind of rhythm. For instance, when we wake up morning after morning within a few minutes of the same time, it may be due partly to how light it is, or to sounds in the neighbourhood, but is very largely due to "habit." Processes in our bodies take place in cycles, and those which occur in sleep are naturally daily cycles. The cycle is rhythmic, and it is difficult to alter it. Thus, if we go late to bed, it is often the case that next morning we wake at the usual time before turning over to go to sleep again. The rhythm has not been upset, and we are all ready to wake as usual. It is not, of course, quite fair to apply this directly to birds, but the analogy is not meaningless. If the rhythmic cycle of feeding and digestion and the desire for more food takes about twelve hours and a half, the tidal rhythm of the gulls' movements is easily understood.

In another place I have described how starlings react to the day-night rhythm.* These birds collect at night, except in the breeding season, to definite roosts, where sometimes there may be hundreds of thousands of birds. If the time they leave the roost is observed regularly, it is found to alter from week to week and month to month. From mid-winter the time gets earlier until April, when breeding starts, and from July it gets later again through the autumn. So, of course, does the time of sunrise. *But the starling's waking-time does not change so quickly as the time of sunrise.* In mid-December they are up and dispersed fifteen minutes before sunrise; by the end of January they are about level with it. In August, when the nights are short, they may wait as much as fifty minutes after sunrise before they leave the roost.

There is thus a compromise between the changing length of night and their internal rhythm, which demands a certain minimum amount of rest in the twenty-four hours. The sunrise-stimulus pulls, and the rhythm acts as a brake, tending to keep the proportions of feeding-time and sleeping-time the same throughout the year.

Rhythms in animal behaviour like the ones described here are not in perpetual motion. We have considered the tidal movements of gulls near Plymouth. Supposing it was possible to extend the mile-long breakwater across the mouth of The Sound, so that it formed a weir from Bovisand to Penlee, right from shore to shore. The tidal streams up and down the Hamoaze and Cattewater would cease, and the water would remain at a constant level. According to the height of our weir, the mud-flats would be covered or exposed, but there would be no alteration in their appearance or in their suitability as feeding grounds. And suppose once more that this super-human engineering feat was done in a single night! We should find, if the rhythm of the gulls is genuine, that they would fly up the next day at the time when the tide *ought* to be going out, to feed up the estuaries. They might do it again the following day, but very soon they would stop. The rhythm would run down because the stimulus was removed. There is an excellent analogy to be found in an engine and its flywheel. Each explosion in the cylinders corresponds to a stimulus, and the flywheel to the rhythm. If the explosions are slightly irregular, the inertia of the heavy flywheel smooths them out, and carries the movement on regularly between stimulations. If we switch off the ignition, which corresponds in the analogy to putting a weir across the mouth of The Sound, the flywheel will run on for some time, but not indefinitely. How long it continues depends on its weight.

An Analogy.

It is clearly impossible to make this grand experiment, but on more lowly animals something similar has been done quite simply. Living on the sandy shores of Brittany is a small marine worm, *Convoluta roscoffensis*, which is interesting in more ways than one. It is very small, but vast numbers live close together, and appear as green patches on the sand. They are green because they contain minute algae (plants), and the algae contain chlorophyll, the green colouring matter of plants. With it they build up organic compounds—starches and sugars—from carbon dioxide and water, a process called photosynthesis because light plays an important part in it. The algae reproduce inside the worm, and the worm

**British Birds*, vol. xxiii, 1929, pp. 172-3.



A GROUP OF BLACK-HEADED GULLS.

The birds here photographed are alighting from flight. Their distinctive markings are clearly seen, and facilitate counting in numerical experiments.

digests their increase, leaving a sufficient number to keep the process going. Ultimately it over-eats the supply and dies, like the whaling industry. It lives on capital and not on interest.

These algae can only photosynthesize in light above a certain intensity. When the tide is in, the sandy water cuts off so much light that it is impossible. The worms therefore bury themselves in the sand when the water comes up the beach, and prevent themselves being washed away. In this way they protect the algae in return for the food-toll. They remain buried until the ebb-tide runs off the beach again. Then they come out on to the surface of the sand, and in the bright light the algae carry out their work of photosynthesis. It is then that the colonies of worms are seen as extensive green patches, which disappear before the flood tide covers them again, and so the whole process is repeated. Professor Keeble, to whom our knowledge of this strange animal is due, took a handful of sand from one of the colonies, with its contents of *Convoluta*, and put it in a dish in the laboratory at Roscoff. He found that the worms went on coming up to the surface and burrowing down into the sand again under the static conditions of the laboratory, exactly as they had done on the shore. Even when they were kept in the dark they behaved in the same way. They kept time with the tide, and with the patches of green which could be seen on the shore from the laboratory windows. After a short time, however, the habit was worn out, perhaps partly because the conditions were not right for algal photosynthesis.

There are a great number of cases of this general type known in the animal and plant kingdoms, but none, I think, is so clear cut as this. Rhythms may have a period of some hours, like those of the black-headed gulls or *Convoluta*, or of weeks (often fortnightly or monthly) or of a year. The migration and reproduction of birds is thought to be rhythmic and regulated by the length of the day. If the switch is turned off, and the day-length is not allowed to change, the annual rhythm can be broken down, as Professor Rowan has shown experimentally. Curiously enough in the tropics, where the switch is always turned off, and the length of the day never changes, there are some species of birds which make migrations to mountain regions from the forests, and *vice versa*, quite regularly every year, although they never leave the tropics in the process. It is not possible to explain this at present, because it looks as if the flywheel was in perpetual motion.

This method of approaching the problem of bird-mind provides very interesting results, although it is narrowly restricted to certain forms of behaviour. The results have the advantage of being clear cut. It is abundantly clear that rhythms play an important part in regulating bird behaviour, principally in preparing them for events before they happen. The starlings, for instance, are all collected to the roost before it gets too dark to see; the gulls are at their feeding grounds before the tide is out. And although it is not yet proved, it is quite possible that the nightjar lays its eggs at a certain phase of the moon, so that when the young hatch out, and the parents have got the arduous task of feeding them, they reap the advantage of having a full moon to extend the period of twilight, and thus to give them more time to find the food. Instinct and rhythm share the place of "intelligence" in birds.

Prizes for Criticism.

THE Editor is informed by the *Sunday Referee* that the prize now offered to Cambridge undergraduates for a critical review of the contents of the issue dated 26th January, will be repeated in subsequent months for members of other universities. One object of the competition is to draw attention to this newspaper in academic circles, where it is believed that the improved features recently introduced will be welcomed. Though its name suggests that the *Sunday Referee* is a sporting paper, this is not the case. The main contents deal with current affairs, politics and industry, and there are now regular book-review pages conducted by Mr. Richard Aldington.

Book Reviews.

The Most Noble and Famous Travels of Marco Polo, together with the Travels of Nicolo de' Conti. Edited from the Elizabethan Translation of John Frampton by N. M. PENZER, M.A. (Argonaut Press. 42s.).

The Argonaut Press has already firmly established itself as the publisher of new editions and revised texts of famous books of travel. In this fine volume it can lay claim to have produced a book of high learning that is at the same time a thing of beauty and a fine example of good typography and binding.

We have, in effect, a new edition of Polo which does not supersede the editions of Yule and Cordier, yet must be read as a corrective to the notes of those editors. Mr. Penzer has had the inestimable advantage of using the maps and researches of Sir Aurel Stein and, in the Malay section, the advice of a Malay scholar, Dr. Blagden. He is thus able to illustrate many of Polo's more obscure journeys with extracts from the surveys of Stein and of other maps not fully accessible to Yule. The text used is of profound interest. It is a translation by John Frampton, who was a Spanish scholar of some eminence who, amongst other things, seems to have some claim for having learnt of the virtues of tobacco some nine years before Raleigh. He was obviously a student of eastern travel, in addition to his other interests. The editor has given a full bibliography of his works. His translation appeared in 1579 from the Castilian translation of Rodrigo Santaella, made itself, apparently, in 1503, from a MS. of the "Venetian Rescension." The Venetian group of manuscripts, which is the largest group of all, contains what are, in some respects, the best. Santaella's version, therefore, which is translated by Frampton, may be looked upon as a new addition to the Venetian group (in the second degree) and Frampton's translation as a new addition in the third degree.

The editor has given us not only a lucid and learned introduction, but also copious notes. The intricacies of Polo's nomenclature are very considerably elucidated, even beyond the stage of elucidation to which Yule and Cordier had brought them. Very considerable help has been available from the recent work of Benedetto on the Polo texts, as well as from topographical and survey work in China and Mongolia. Increased knowledge of the Persian region as well as of Central Asia has made it possible to establish much new information on a firmer ground. Thus, for instance, the route of Polo, from Bafk to Hormuz, is now almost certainly defined exactly. Yule here stands corrected. Baghdad and the Persian Gulf fall finally out of the itinerary. So, too, at the other end of the journey, the route through the Malay archipelago seems fixed with greater probability. The value of such increased accuracy is manifest. Polo's narrative derives increased value year by year. No doubt, in time, this edition also will be superseded, as archaeological and topographical discovery increase in quantity. But the progress of research in Asiatic regions is, by force of circumstance, extremely slow. Political conditions and the rigours of climate make travel in many parts of the areas covered by Polo's itinerary difficult, and almost impossible. Even in more accessible Seistan, and south of it, there are areas which have not been visited by Europeans since the time of Alexander, and Polo can still claim a monopoly of knowledge of the bulk of the country he traversed. Nevertheless, journeys like those of Sir Aurel Stein, and research

like that of Dr. Lecoq, at Turfan, do more to fix the sites of towns and establish ancient trade-routes than all the conjecture of learned scholars who have never left their libraries. The Polo family were pioneers in the science of geography as well as in that of trade. But that they struck out new routes and abandoned the ancient ways of traffic is highly improbable. The fixing of their routes therefore has the deepest importance for the study of the history and pre-history of Asia. Even in the remote Neolithic period the Chinese province of Kansu seems to have been an emporium to which the races and influences of the west penetrated in force, to judge by the recent ceramic discoveries of Professor Andersson of Stockholm. Polo may have been treading one of the oldest roads of Asia when he reached the town of Kan-Chau.

The editor has included in an appendix selections from the travels of Conti, from a further translation by Frampton. The use of these in the same volume is inestimable.

The Cambridge University Press are to be congratulated on the printing, which places the book in the front rank in quality of typography, and the publishers deserve praise for giving so beautiful a frontispiece—a reproduction in colours of the miniature in the Bodleian Library which shows the departure of the Polos from Venice. Altogether the book is one which will be much sought for as an adornment to any good library.

STANLEY CASSON.

Anthropology in Modern Life. By FRANZ BOAS. (Allen & Unwin. 10s. 6d.).

Anthropology has not yet come into its own as a science applicable to the everyday problems of modern life. Slowly its value as a factor in the administration of the affairs of backward peoples is becoming more widely accepted. It is now realized that it is to the advantage of both governors and governed that officials should have studied the institutions and beliefs of the people over whom they rule; still more that they should acquire the sympathetic understanding of the mentality which underlies non-European cultures that is either the fruit of long familiarity or can be acquired only by systematic study and anthropological training. Yet outside the circle of a few it is little appreciated how far the science can be brought to bear upon the problems of a modern civilized community. It is a remarkable thing that at the present day when there is a widely-felt desire to approach social problems in a spirit of scientific enquiry we are almost entirely lacking in the knowledge of the anthropological data which should be fundamental in seeking a solution, if not of all, at any rate of many of these problems. For example, in the present state of our knowledge it is desirable to investigate the relation of the incidence of cancer to race. A recent study of the statistics of cancer in England and Wales by M. Pittard has attempted to discuss this aspect of the question. The geographical distribution of cancer in Britain is extremely interesting, but it is puzzling. When, however, an attempt was made to see how far questions of race entered into the problem of distribution, the results were practically worthless because for certain areas the requisite knowledge of the racial composition of the population and records of their physical characters were entirely lacking.

In the United States some interesting if not always judicious attempts have been made to apply the data and the results of anthropological study to social and educational problems. The variety of races within the States and the frequency of racial crosses of the various white races and of white, black

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and red, offer a fruitful field for observation in both physical and mental characters. Some useful results have been obtained, but many more, unfortunately, have little significance. Over-hasty generalization has been made subservient to political ends. The struggles in recent years over immigration made such a phrase as the "Nordic Race" a popular catchword. It is no doubt for this reason that in "Anthropology and Modern Life" the critical caution of its author is more strikingly impressed upon the reader than the constructive value he attaches to anthropology. Yet he regards it as an essential study for the practical organization of life on lines in harmony with the trend of development and the principles of growth in human society. Working on these lines, he himself is led along the paths of speculation to some very interesting conclusions in world politics. But the loose use of such terms as "race," "heredity," "environment" and the like from which much popular argument acquires a pseudo-scientific flavour is ruthlessly criticized, and these terms are reduced to their strict scientific connotation before any deduction from them is attempted. The eugenists in particular receive some wholesome, and, perhaps, not too harsh criticism.

Professor Boas' book is more directly applicable to intellectual conditions in America, but it is also valid in its conclusions for this country. It will serve as a useful reminder that many of the problems of anthropology which bear upon social progress are still *sub judice*, and that premature generalization, and still more premature action on such generalization, does more harm than good.

E. N. FALLAIZE.

The Assyrians and their Neighbours. By the REV. W. A. WIGRAM. (G. Bell & Sons. 15s.).

The people who are the subject of this book must be almost, if not entirely, unknown to the general run of readers. Few perhaps realize when they read the accounts of recent archaeological exploration in Mesopotamia, that the descendants of the builders of this early culture still survive in the land and that the kingdom of Iraq includes in its subjects a people who, like the Egyptians, can trace back an unbroken line of descent to the early, if not the earliest, inhabitants of their country. It is true they do not appear as a separate entity at the earliest stages of Mesopotamian history; but they were of the Semitic stock which joined with the Sumerian. Possibly they then preserved their original racial character in some degree of purity. This would account for their intolerance of the rise of Babylon and their migration northward, and for much that was distinctive in their later history. As we know from their own records, the early Assyrians were a virile and warlike race; and they preserved a certain individuality in type throughout the vicissitudes of their history. Mr. Wigram, after briefly surveying the earlier history of the Assyrians, takes up their story from the time of Alexander, and traces it, with that of their immediate neighbours, through the troubled Roman times, the Mongol invasions, and under Mohammedan and Turk, when they were a Christian island in a vast sea of Islam. He shows how their peculiar racial character stubbornly resisted pressure—in this recalling the Jews—until the Great War, when they fought on our side. The final episode of their share in that struggle was characteristic. The whole nation, when apparently at the point of complete extinction, broke through the Turkish army and reached safety in Persia. From beginning to end their history makes a stirring tale which is here well told.

Ends of the Earth. By ROY CHAPMAN ANDREWS. (Putnam. 16s.).

It would be interesting to know whether the title of this book of adventure, written at the suggestion of Mr. G. P. Putnam and dedicated to him, was chosen by the publisher or the author. It is appropriate in every sense, since the pages describe experiences in many parts of the world—such as Borneo, China and the Arctic—and, moreover, were written and dispatched while Mr. Andrews was travelling on another expedition. As he explains at the outset, the book "has been written on trains and ships, a part of it even in an aeroplane. Chapters have been mailed from cities on the west coast, from Honolulu, Yokohama and Peking." A promise had been given to complete the manuscript before the author left for the Gobi desert in the summer of 1929, and the excellent production which has now followed is a tribute to the publisher.

Roy Chapman Andrews attracted wide notice by his discoveries in the Gobi Desert in 1922, 1923 and 1925, when among other spectacular finds he unearthed a nest of twelve dinosaur eggs. The results of this work he embodied in a book, "On the Trail of Ancient Man," of which the present volume is really the predecessor. For most of it describes the explorer's adventures in the ten years before, which were spent in gaining experience in many minor expeditions. To illustrate the style, a passage may be quoted describing a later incident in China, during 1926. Evidently the Civil War makes travelling a precarious business for foreigners, for on one occasion Mr. Andrews' route took his party through an apparently deserted region, close on the heels of a military detachment. As a certain bridge was approached another mass of soldiers suddenly appeared and open fire with a machine-gun.

"Fortunately at this particular spot the road was wide enough for the car to be turned and I swung it about in record time. The bullets now were buzzing like a swarm of bees just above our heads. Forty yards down the road a sharp curve took us out of sight of the machine-gun. The other men crouched in the bottom of the car. Since I was driving I could see all the fun. It was a pretty rough road, but the speedometer showed fifty miles an hour as we went back. The ride became an exciting one. All the houses which had seemed so peaceful actually were occupied by the advance guards of Fengtien soldiers. They had let us pass because of the American flag, but when they heard the firing in our rear and saw us returning at such mad speed, they evidently thought that we were anybody's game. Each and every one decided to take a shot at us." Eventually the situation was eased by the appearance of an officer who could speak Mandarin Chinese, instead of the Shantung dialect, and the car was allowed to return unmolested to Peking. "The only reason why we were not riddled with bullets," Mr. Andrews explains philosophically, "is because the Chinese soldier is the world's worst rifle shot."

Handbook of the Geology of Great Britain. A Compilative Work, edited by J. W. EVANS, C.B.E., D.Sc., F.R.S. and C. J. STUBBLEFIELD, Ph.D. (Thomas Murby & Co. 24s.).

Little more than a century ago it was possible for one man, William Smith, to describe and map the rocks of the whole of England and Wales, and even as recently as the beginning of the present century Jukes-Browne was able to prepare, single handed, an account of British stratigraphy. But during the last few decades so many new workers have entered the field, and so many refinements have been introduced into the methods

of investigation, that one individual can no longer deal authoritatively and from personal experience with the rocks of all the geological formations represented in Great Britain. Indeed, in a review of Jukes-Browne's book it was suggested that "a work of this description can in the future only be successfully brought out if produced under the auspices of a combination of specialists." On this account, a handbook contributed to by nearly a score of geologists, each an authority in his own particular sphere, should be a welcome addition to the literature of British geology.

This work, of which Dr. J. W. Evans is the senior editor, certainly justifies its publication. Prefaced by a very brief account of the general structure and make-up of our island, the bulk of the book is devoted to the British representatives of each of the geological Formations. Although there is uniformity in typographical and bibliographical details, the editors wisely refrained from aiming at uniformity in the subject matter of the various sections, and each Formation has been accorded the treatment that seemed most appropriate to it. We find, for example, that while the rocks in the Silurian System are dealt with primarily according to the stratigraphical subdivisions to which they belong, the discussion of those of the Carboniferous Limestone formation has a geographical basis.

The igneous rocks have received separate treatment in relation to the strata with which they are associated, and there are brief notes upon the physiographical conditions of each of the successive periods, and upon the economic products of each of the Systems.

The correlation tables in which contemporaneous strata of various districts are compared, are of especial use to the student as also are the bibliographies. The unusually exhaustive index runs to twenty-four closely printed pages, and adds greatly to the value of the work, which must for many years remain a standard work of reference. While specialists will undoubtedly find certain expressions of opinion to which they cannot entirely subscribe, the book can be accepted, in general, as an authoritative summary of the present state of knowledge in this subject. A point that might be corrected by those who possess the book is that the output of iron ore from South Wales and the Forest of Dean during the period 1918-1925 (page 224) was in the neighbourhood of 500,000 tons. The figures given (38,000) relate only to the Forest of Dean.

F. J. NORTH.

Modern Gramophones and Electrical Reproducers. By P. WILSON and G. W. WEBB. (Cassell. 10s. 6d.).

In the foreword to this volume Mr. Compton Mackenzie states that "a combination of Mr. Webb's vast experience and knowledge, with Mr. Wilson's mathematical genius for being right could not be improved upon by any combination of experts of which I am aware . . . They would be the last people to claim that they have said the final word about the gramophone of to-day; but they have in this volume built up such a solid foundation that it is not rash to suggest that for some time to come it will not be shaken, and that further information will be in the nature of a supplement to this volume." Progress in the design of the gramophone has recently been extremely rapid, so that had a work of this nature been published two years ago it would now certainly have become obsolete. Two years further progress may, however, render this treatise out-of-date, though the authors tell us that they are confident

that the fundamental principles are now well established, and the paths of further progress clear.

There is a short introductory chapter on sounds and sound waves, and some concluding miscellaneous hints about the care of instruments and records. The main portion of the volume is, however, devoted to an historical and descriptive account of records and recording systems, reproducing systems, sound boxes, horns, tone arms, electric pick-ups, loudspeakers, and electric amplifiers. There are also explanations of the elimination of a great part of the surface noise and record wear and of the evolution of the needle. In order to prove of service to the ordinary man as well as to the expert, the use of mathematical formulae has been kept within small limits a *verba* explanation being used instead wherever possible. There are numerous useful plates and figures.

Ur of the Chaldees: A Record of Seven Years of Excavation
By LEONARD WOOLLEY. (Ernest Benn. 7s. 6d.).

Some years must necessarily lapse before the full results of Mr. Woolley's expedition can be published. One volume on al Ubaid has already appeared, while many discoveries have been described in the author's more popular book "The Sumerians." But prior to the book under review, no consecutive story has been told and it is written to fill the gap.

As long ago as 1854 the British Consul at Basra investigated certain sites in Mesopotamia on behalf of the British Museum. While digging on the Mound of Pitch he unearthed inscriptions which showed it to be the site of Ur of the Chaldees, the home of Abraham. In the 'eighties an expedition from Pennsylvania University did a little digging, without publishing any results. The British Museum had long hoped to follow up its original discovery, but it was not until after the War, in the winter of 1918-19, that further excavations were made, by Dr. H. R. Hall. Lack of funds then caused yet another halt. In 1922 the American university which had worked in the last century came forward and proposed a joint expedition, with the outcome that in the following years the now world-famous discoveries were made. As director of the expedition Mr. Woolley has unique advantages for writing about its work, and he is to be congratulated on a narrative that is thoroughly informative without ever being dull. The book itself is of pocket size, has many good photographs, and includes a plan of Ur, so arranged that it can be conveniently studied in conjunction with any page of the text.

The reports published from time to time have dealt mainly with special topics—such as the wonderful gold-work discovered in the tombs—and it has been difficult for the layman to trace any clear theme throughout the whole period. To such readers Mr. Woolley's little book will be specially welcome. Beginning with the Flood, the chapters lead on, through an account of the kings, to the earliest written history discovered at al Ubaid, and then on to what the author aptly terms the Great Days of the Third Dynasty. The next section, on the buildings of the Larsa Kings, contains an interesting picture of a house at the time of Abraham, which shows how very ancient are the ideas which still find expression in the architecture of to-day. Some indication of the remote antiquity of Ur is also given by the next chapter title, the "Middle Age" of Babylon, a city previously associated with some of the earliest historical records. The period of Nebuchadnezzar concludes Mr. Woolley's book, which throughout combines a practical account of the expedition with the historical story surrounding each of its many discoveries.

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